2. To: (Receiving Organization) B&W Hanford Company	3. From: (Originating Organization) FDNW Criticality and Shielding	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Plutonium Finishing Plant	6. Design Authority/Design Agent/Cog. Engr.: B. S. Mo	7. Purchase Order No.: N/A
8. Originator Remarks: This document is being approved for release.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 234-5Z
		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
11. Receiver Remarks:		14. Required Response Date: N/A
11A. Design Baseline Document? ☒ Yes ☐ No		

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-6537	-	0	CSEER 00-003:	S	1	1	
				Criticality Safety				
				Evaluation Report For				
				PFP Magnesium Hydroxide				
				Precipitation Process for				
				Plutonium Stabilization				
				Glovebox 3				

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Design Authority B. S. Mo	<i>[Signature]</i>	6/29/00	T5-54	1	1	Orig. Eng. JS Lan	<i>[Signature]</i>	6/29/00	B4-44
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		Env. N/A									

18. <i>[Signature]</i> 6/29/2000 J. S. Lan Signature of EDT Originator	19. <i>[Signature]</i> 6/29/00 B. S. Mo Authorized Representative for Receiving Organization	20. <i>[Signature]</i> 7/5/00 J. F. Durnil Design Authority/Cognizant Manager	21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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		EDT No. 622294			
		ECN No. N/A			
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Precipitation Process for Plutonium Stabilization Glovebox 3

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Precipitation Process for Plutonium Stabilization Glovebox 3

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Date Published
May 2000

Prepared for the U.S. Department of Energy
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U.S. Department of Energy under Contract DE-AC06-96RL13200

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P.O. Box 1000
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Chris Killingham 7-12-00
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Printed in the United States of America

Total Pages: 152

CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Precipitation Process for Plutonium Stabilization Glovebox 3

Key Words: Magnesium Hydroxide, Precipitation Process, Glovebox 3, PFP, Criticality Safety, Fissile Material, Precipitators, $\text{Mg}(\text{OH})_2$, Filter Basin, Hot Plate, Flocculent, Vacuum system

Abstract: This Criticality Safety Evaluation Report analyzes the stabilization of plutonium/uranium solutions in Glovebox 3 using the magnesium hydroxide precipitation process at PFP. The process covered are the receipt of diluted plutonium solutions into three precipitation tanks, the precipitation of plutonium from the solution, the filtering of the plutonium precipitate from the solution, the scraping of the precipitate from the filter into boats, and the initial drying of the precipitated slurry on a hot plate. A batch (up to 2.5 kg) is brought into the glovebox as plutonium nitrate, processed, and is then removed in boats for further processing. This CSER establishes limits for the magnesium hydroxide precipitation process in Glovebox 3 to maintain criticality safety while handling fissionable material.

CSER 00-003:
Criticality Safety Evaluation Report for PFP
Magnesium Hydroxide Precipitation Process for
Plutonium Stabilization
Glovebox 3

JUNE 29, 2000

Prepared by
Fluor Federal Services, Inc.
Richland, Washington

For
Fluor Hanford, Inc.
In support of
Contract No. 65100241
Task No. 5204-12

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Classifier/RO: MLL/dlt Date: 7/11/00
Title: ENGINEER

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1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

The Magnesium Hydroxide Process is one of the Plutonium Stabilization tasks at the Plutonium Finishing Plant (PFP). This process stabilizes plutonium that is stored as a solution by converting it to an oxide.

The plutonium bearing solution consists primarily of plutonium nitrate, $\text{Pu}(\text{NO}_3)_4$, in an aqueous nitric acid, HNO_3 , solution. Solutions greater than 450 g Pu/L are not expected because both PUREX and PFP have always had a limit of 450 g Pu/L on plutonium nitrate solutions. Two independent determinations of the feed fissionable concentration are made before the batch is pumped to Glovebox 3. The container label listing of fissionable material and lab analysis of a sample are two methods usually used to make the determination of the feed fissionable material concentration. The primary product of the precipitation process is plutonium hydroxide, $\text{Pu}(\text{OH})_4$. The precipitate filtered out of the filtrate is called filter cake and contains approximately 50 wt% water. Moisture may be driven off the $\text{Pu}(\text{OH})_4$ precipitate by heating on a hot plate. This and further heating converts the hydroxide to an oxide suitable for storage. The plutonium oxide in the resultant solids would have a density of less than 1 g Pu/cm^3 . The filtrate will normally have a plutonium concentration less than the concentration limit for the ultimate disposal system. Material that is above the disposal limit will be recycled through the precipitation process until it meets the disposal limit.

The process carried out in Glovebox 3 is the receipt of diluted plutonium solutions into the three precipitation tanks, the precipitation of plutonium from the solution, the filtering of the plutonium precipitate from the solution, the scraping of the precipitate from the filter into boats, and the initial drying of the precipitated slurry in a boat on a hot plate. Material accountability may require that this process be completed and the glovebox emptied of all the plutonium brought in as a batch that filled the three precipitation tanks before another batch may fill the tanks. However, this criticality analysis would allow operations to process up to six batches simultaneously in Glovebox 3. A batch is allowed to have up to 2.5 kg of plutonium. A batch is brought into the glovebox as plutonium nitrate and is removed in boats for stabilization. The boat dock can store up to two boats. If the filtrate that is sent to Glovebox 4 needs to be brought back to Glovebox 3 for further processing, the filtrate would be treated as a separate batch. The filtrate cycled through Glovebox 3 to take a sample to determine the plutonium concentration in the filtrate need not be considered a batch.

Operations makes two independent determinations of the plutonium concentration in batch of nitrate feed solution coming into Glovebox 3. First, information contained on the label on the storage container is used to make up a blend plan that sets the solution concentration to be sent to Glovebox 3. Lab analysis results of a sample taken from the blended solution in the blend tanks prior to pumping the solution to Glovebox 3 is the second determination of the plutonium concentration of the blended solution in the blend tanks. A second independent sample of the blended feed solution may be used as the second determination of the fissionable material concentration.

This CSER shows that the magnesium hydroxide process to be run in Glovebox 3 is acceptable when controlled to the limits listed in Section 3.0. No single credible event has a k_{eff} containing the computer code bias and calculational uncertainty that exceeds the criticality safety limit of 0.95.

1.2 DOUBLE CONTINGENCY DOCUMENTATION

This section presents a summary of the expected operations, the expected normal conditions, and the base case for normal conditions plus anticipated off-normal conditions for the precipitation glovebox. A hazards assessment described in Section 4.4 is used to systematically identify off-normal events and classify them as likely or unlikely events. The likely events become part of the base case while unlikely events are analyzed as contingencies. Table 1-1 lists the criticality limits and base case conditions for each criticality parameter. Table 1-2 summarizes the bounding contingency events.

1.2.1 Expected Operation

The process design would have operators pump approximately 12 L of up to 50 g Pu/L of plutonium nitrate in a nitric acid solution into each of three 20 L capacity 6-in. diameter precipitation tanks. The concentration and volume of the feed solution are selected to fill the three precipitation tanks in Glovebox 3 up to a total design loading of 1.8 kg of plutonium. The three precipitation tanks are allowed to contain up to a total of 2.5 kg of plutonium in a plutonium nitrate solution. This mass limit allows operational flexibility in the concentration/volume combinations used. The 2.5 kg plutonium limit for the precipitation tanks sets a mass limit for the basin and boats that are allowed only one batch of precipitate from the precipitation tanks.

Magnesium hydroxide is added to neutralize the solution and precipitate the plutonium as $\text{Pu}(\text{OH})_4$. Operators use a vacuum sparge to agitate the tank contents to facilitate the precipitation of the fissionable material. The addition of a few milliliters of organic polymer flocculent speeds the settling of precipitate out of the solution by acting as attachment centers for plutonium precipitate. The precipitate and solution are gravity drained through flexible plastic tubing to a 17-in. diameter filter on the vacuum filter basin. Filtrate is removed by drawing a vacuum on the outlet side of the filter. The filtrate is collected in a phase separator tank, then pumped through a polishing filter and out of the glovebox to Glovebox 4 for disposal.

Operators scrape plutonium precipitation cake with approximately 50 wt% water from the filter into a 5-in. by 11-in. by 2.5-in. deep furnace boat that has a 2.25 L volume. A hot plate reduces the water content of the plutonium. The boat is passed thru Glovebox 5 to conveyor HC-3 that moves the boat to a muffle furnace in another glovebox for further high temperature processing.

1.2.2 Conservative Normal Operating Conditions

Plutonium nitrate solutions stored at the PFP are allowed to have concentrations as high as 450 g Pu/L. These solutions are blended with nitric acid to reduce the concentration to approximately 50 g Pu/L before pumping the solution to the precipitator tanks in Glovebox 3. The maximum feed concentration is arbitrarily set at 100 g Pu/L, twice the process design value, to set a base case limit. At 100 g Pu/L concentration, the 2.5 kg limit on plutonium mass in the precipitation tanks limits the total solution volume to 25 L. The feed solution is pumped into the precipitation tanks through several control valves and the piping at the bottom of the tanks. Interlocked valves control filling the tanks and all other fluid movements in Glovebox 3. However, the criticality analysis does not utilize the valve interlocks. The upset conditions have the tanks filled with the most reactive concentration of plutonium nitrate solution.

The plutonium nitrate is precipitated from the nitric acid solution by the addition of magnesium hydroxide to neutralize the nitric acid. The operators assure that all the plutonium precipitates by adding 5 wt% excess magnesium hydroxide and agitating the tank contents. They also add flocculent to speed settling. A filter removes the precipitated plutonium hydroxide $[\text{Pu}(\text{OH})_4]$ from the filtrate by pulling a vacuum below the filter. The filter cake is usually about 50 wt% water, but can be higher. Boats are modeled filled with plutonium oxide mixed with water. Operators scrape the filter cake, typically containing 1.8 kg of plutonium from the filter into a furnace boat or boats. The upper limit on a precipitation batch is established by limiting the total plutonium mass in the feed solution to the three precipitation tanks to 2.5 kg of plutonium. This limit is not necessary for the precipitation tanks, which can safely contain 18 kg each. This limit sets a maximum to the amount of plutonium in a batch in the remaining processes in the glovebox to 2.5 kg. This limit is made because precipitation divides the plutonium in the feed solution between the precipitation cake and filtrate by a ratio not determined until the precipitation cake and filtrate leave the glovebox. The masses in the filter basin and boats in Glovebox 3 depend on determination of the concentration and volume of the feed solution pumped to the three precipitation tanks.

A boat is heated on top of a hot plate to reduce the water content in the filter cake. A 1 in. square bar separates two boats in the boat storage area. Boats are passed through a dog leg pass through, Glovebox 5, to a conveyor to move them to other gloveboxes for further processing.

The effect of operators' hands, rags, piping, plastic tubing, and equipment is modeled as one inch of water reflector around parts of the tanks, filters, and boats. Operators' bodies are modeled as twelve inches of water reflector around the sides of the glovebox. Even though it is difficult for operators to get under the glovebox or to store fissionable or reflective material under the glovebox, full water reflection of six inches (page II.E-2 of ARH-600 [Carter 1968]) is modeled directly below the glovebox floor. An eighth inch layer of 3 g Pu/cm³ on the glovebox floor and conservative diameter of the precipitation tanks accounts for the sweeps can, leak detection bottle, sample bottles, and trash bags in the glovebox. The water under the glovebox is conservative because bracing on the lower sides of the glovebox make storage or operator access under the glovebox difficult. One inch of water above the glovebox models the reflection of the ceiling, which is more than three feet above the top of the glovebox, and water lines, electrical

conduit, vacuum piping, and other plant equipment. Additional modeling parameters for normal conditions are presented in Section 5.1.

1.2.2 Base Case Conditions

The base case encompasses the normal conditions, described above, along with anticipated upset events. Table 1-1 summarizes the limits for normal conditions and lists the abnormal but anticipated conditions for each criticality parameter. The combination of normal conditions allowed by limits and anticipated abnormal conditions are used to evaluate the criticality safety of normal operations in Glovebox 3 as the base case. Each contingency is analyzed by adding it to the base case. Section 5.2 of this CSER presents analyses of the base case conditions. The k_{eff} for the base case described in this section and in Section 5.2 is 0.882.

Table 1-1. Summary of Base Case Limits

Controlled Parameter	Limit	Abnormal but anticipated Conditions
Mass	≤ 2.5 kg Pu per boat; Maximum of four boats in Glovebox 3; Maximum of one boat in Glovebox 5. ≤ 2.5 kg Pu in vacuum filter basin; ≤ 2.5 kg total Pu in precipitation tanks;	2.75 kg Pu per total in precipitation tanks, in the basin, and in a boat; Precipitation tank full (20 L) of 450 g Pu/L (9 kg) precipitated to 6 in. of 3 g Pu/cm ³ in the bottom of each precipitator tank
Volume	≤ 2.3 L/boat, up to 4 boats inside Glovebox 3, 1 boat in the Glovebox 5. ≤ 20 L/precipitation tank; ≤ 20 L/phase separator tank; ≤ 11.1 L vacuum trap tank; ≤ 5.5 L vacuum catch tank; nominal $\frac{1}{2}$ L sweeps can; one L bottle for leak detection; three nominal 250 mL sample bottles; Twelve 50 mL sample bottles.	None
Moderation	Fire Fighting Category C.	None
Interaction	Four (4) boats are allowed in Glovebox 3: two boats in the boat dock and one boat each at the hot plate and at the vacuum filter basin; one boat may be anywhere except within 25.4 cm (10 in.) of the glass tanks in Glovebox 3. Remove all fissionable material except holdup prior to changing HEPA filter.	A boat under precipitation tanks with 2.75 kg Pu.
Reflection	Criticality drain visibly unobstructed. No close fitting material around tanks.	None

Controlled Parameter	Limit	Abnormal but anticipated Conditions
Geometry	Maximum of 6.2 in. inside diameter of tanks, pump, surge tank, and piping. Three precipitation tanks maintained in a line. Filter basin is limited to nominal 17 in. diameter, maximum of 2.1 in. depth above and 1 in. depth below the perforated filter plate. Boats limited to nominal 2.5 in. depth. Filter drip pan is limited to nominal 2 in. depth.	Tanks modeled at 6.3 in. inside diameter; Filter left out of the vacuum filter basin.
Isotopics	None	None
Enrichment	$\leq 50\%$ U-235 in U.	None
Density	Pu or U metal prohibited in Glovebox 3.	None
Concentration	Feed solution ≤ 100 g Pu/L	450 g Pu/L feed solution.*
Poisons	None.	None

* Section 5.2 shows that 250 g Pu/L is the most reactive plutonium nitrate solution over the range of 0 to 450 g Pu/L.

1.2.3 Contingency Conditions

Table 1-2 summarizes the analyses of the unlikely, independent, non-concurrent off-normal events (contingencies). Each event is assumed to occur with the glovebox configured as the base case with the contingency condition added. This list provides a conservative envelope of the off-normal events. This table summarizes the results of the contingency evaluations documented in Section 5.3 of this CSER.

Table 1-2. Glovebox 3 Contingency Summary

Contingency Description	Affected Criticality Parameter(s)	Barriers that make contingency unlikely	k_{eff} bounding contingency (case ID)
Seismic event with glass tanks breaking and sprinkler water added	Reflection Moderation	Seismic event unlikely; requires severe damage from seismic and concurrent sprinkler water inflow into the damaged glovebox. Criticality drain limits depth of water on glovebox floor. Limited volume water supply.	$k_{eff} = 0.9359$ $\sigma = 0.0005$ (cc5)

Contingency Description	Affected Criticality Parameter(s)	Barriers that make contingency unlikely	k_{eff} bounding contingency (case ID)
20 L of 450 g Pu/L (9 kg) in each of 3 precipitation tanks precipitated to 15.2 cm (6 in.) of 3 g Pu/cm ³ in the bottom of the three tanks with the remainder of the tank filled with 250 g Pu/L	Mass Concentration	Operations makes two independent determinations of the fissionable material concentration in each batch. Tank diameter protected by configuration management. Operator training/procedure	$k_{\text{eff}} = 0.8884$ $\sigma = 0.0005$ (cc1)
Precipitation tanks, vacuum tanks, phase separation tank filled with 250 g Pu/l plutonium nitrate solution with 15.2 cm (6 in.) of 3 g Pu/cm ³ of PuO ₂ solids in the bottom of the three precipitation tanks	Mass Interaction	Operator training/procedure, Equipment or processing failure allowing concentrated solution into all the tanks. Tank diameter protected by configuration management.	$k_{\text{eff}} = 0.8932$ $\sigma = 0.0005$ (cc2c)
Double batched boat in boat dock	Mass	Operator training/procedure/inventory control	$k_{\text{eff}} = 0.8860$ $\sigma = 0.0005$ (cc3)
Boat stacked on two other boats	Mass Interaction	Operator training/procedure	$k_{\text{eff}} = 0.8871$ $\sigma = 0.0006$ (cc4)
2 x 2 boat array in a corner of the glovebox	Mass Volume		$k_{\text{eff}} = 0.9312$ $\sigma = 0.0005$ (cc103)
Aggregate of containers	Mass Volume	Operator training/procedure	$k_{\text{eff}} = 0.8864$ $\sigma = 0.0005$ (cwcc7)
Container with 4.5 kg of Pu brought up to outside of glovebox	Interaction	Operator training/procedure	$k_{\text{eff}} = 0.9105$ $\sigma = 0.0006$ (cc7)
Double batched filter basin mass of 5.5 kg Pu	Mass	Operator training/procedure/inventory control	$k_{\text{eff}} = 0.8741$ $\sigma = 0.0005$ (cc8)
Interspersed moderation at full water density without glass tanks breaking	Moderation Reflection	Requires glovebox windows breaking by seismic or major fire, both unlikely. Tank spacing protected by configuration management.	$k_{\text{eff}} = 0.9410$ $\sigma = 0.0014$ (cc1121)

Contingency Description	Affected Criticality Parameter(s)	Barriers that make contingency unlikely	k_{eff} bounding contingency (case ID)
		Limited volume water supply.	
Seismic event reduces spacing between precipitation tanks	Interaction	Seismic event unlikely. Tank diameter protected by configuration management.	$k_{eff} = 0.9207$ $\sigma = 0.0014$ (ncs2)
Uranium enrichment greater than 50 wt %	Enrichment	Feed limited to less than 50 wt % uranium. Feed limited to less than 100 g Pu/L	Bounded by evaluated Pu concentration of 100 g Pu/L.
Fire	Moderation Reflection	Major building fire that breaks glovebox windows to allow sprinkler water in is unlikely. Criticality drain limits water level.	Bounded by seismic $k_{eff} = 0.9359$ $\sigma = 0.0005$ (cc5) and interspersed water $k_{eff} = 0.9410$ $\sigma = 0.0014$ (cc1121)

1.3 SUMMARY

This CSER shows that the designed magnesium hydroxide process controlled to the limits listed in Section 3.0 is acceptable in Glovebox 3. No single credible event causes the k_{eff} criticality safety limit of 0.95 to be exceeded. All the contingency calculations meet the calculational limit of $k_{eff} = 0.942$ specified in Appendix B which is used to account for bias and computational uncertainty. Therefore, this CSER meets the requirements of the Double Contingency Principle for a criticality safety analysis specified in the Hanford Site Nuclear Criticality Safety Manual (HNF-PRO-539).

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2.0 SYSTEM DESCRIPTION AND NORMAL OPERATION

This section gives a system description of the magnesium hydroxide process, including both the precipitation stream and the interim filtrate storage. A schematic diagram for this process is shown in Figure 2-1.

2.1 SYSTEM DESCRIPTION

The operation begins with loading in plutonium nitrate solutions to the blend tanks in the preparation Glovebox HC-227S. The solutions are sampled, blended, and adjusted with dilute HNO_3 to meet the blend plan for precipitation in Glovebox 3.

The adjusted feed material is pumped to three precipitator tanks in Glovebox 3, where an amount of dry $\text{Mg}(\text{OH})_2$ powder calculated to neutralize the batch of feed solution (plus a 5% excess to assure complete plutonium precipitation) and about a teaspoon of flocculent are added to each precipitator tank. The solution is agitated for a given period of time with air drawn through the solution by the glovebox vacuum system eductor. The precipitate and filtrate is drained to a filter, where the liquid (filtrate) is drawn off to the phase separator tank using the glovebox vacuum system. If the filter pan does not drain, fissionable material will overflow the filter basin to the floor of the glovebox. The event of having fissionable material on the glovebox floor is analyzed.

When the liquid has drained from the precipitate cake, the cake is manually scraped off the filter into a standard furnace boat, which is placed on a hot plate to reduce the water content of the cake. A scale will be available inside the glovebox to determine the mass in a boat. After the cake is dried, the boat is moved to a boat dock or to the conveyor and transported to other gloveboxes for thermal stabilization.

The filtrate is pumped from the phase separation tank through one of a pair of polishing filters to one of three pairs of filtrate tanks in Glovebox 4. The filtrate is circulated through Glovebox 3 to be sampled for analysis of the plutonium concentration. If the filtrate analysis meets disposal specification limits, the filtrate will be drained to 241-Z or to another facility for storage and disposal. If the filtrate analysis does not meet disposal limits, it can be pumped (recycled) back to the precipitator tanks, or through the polishing filters, or pumped among the filtrate tanks for blending. The polishing filters have pressure differential instrumentation to show when to change out the filters. The vacuum catch tank and vacuum trap tank would not be expected to collect significant fissionable material during normal operations, but they are filled with fissionable material for the contingency case cc2c (Section 5.3).

2.2 FACILITY AND EQUIPMENT DESCRIPTION

The magnesium hydroxide precipitation process includes the following subsystems (Zook 1999):

Feed Preparation

Plutonium feed is received in solution containers (e.g., PR cans, 10Ls, etc.) and transferred to blend tanks in Glovebox HC-227S using the plant vacuum system. The blended feed solution is then pumped to the magnesium hydroxide process precipitate tanks in Glovebox 3 by an existing air operated diaphragm pump through a single encased transfer line (a pipe-within-a-pipe).

Glovebox 3 does not have limits on molarity of nitric acid for temperature ranges because it is not considered credible that plutonium solutions that are susceptible to polymerization can be blended and then pumped to Glovebox 3. Polymerization would occur in the blend glovebox or in the transfer line before reaching Glovebox 3. Glovebox HC-227S where the fissionable solutions are blended has limits on nitric acid concentration to prevent plutonium polymerization.

Precipitate

The chemical conversion of plutonium nitrate to a plutonium precipitate of plutonium hydroxide occurs when magnesium hydroxide changes the solution from an acid holding the plutonium in solution to a basic medium. The following reactions occur:

When the precipitate has settled, a sample is taken from the precipitators to ensure that the solution is above a pH of 6.2. This minimum pH controls the maximum concentration of plutonium that can remain in solution. Although the plutonium concentration remaining in solution is not measured at this point, if the pH is above the minimum value, the plutonium remaining in solution would meet the waste treatment facility ultimate disposal acceptance criteria.

Vacuum transfer and filtration

The slurry of precipitate and solution in the precipitation tanks will be gravity drained to the vacuum filter to separate the plutonium precipitate from the filtrate stream. The vacuum on the filter will pull the filtrate through the filter while leaving the plutonium hydroxide solids on the filter media. The filtrate will be collected in a phase separator (disengaging pot) to remove the entrained air from the filtrate prior to pumping this material through polishing filter and into the filtrate tanks in Glovebox 4.

Drying on the hot plate

Operators will scrape the plutonium filter cake into a boat. The boat is then placed on a hot plate to reduce the moisture content. The boat containing the plutonium solids will then be transferred to a muffle furnace in another glovebox via conveyor. A worn out filter is dried on the vertical line and bagged out as waste.

Filtrate transfer and polishing filters

The filtrate will be pumped through one polishing filter. These polishing filters contain a sock filter to catch smaller particles of plutonium hydroxide that passed through the vacuum filter. The two filters are in parallel to allow switching from one filter to the other when an excessive pressure drop indicates one filter is full. The polishing filters have pressure differential instrumentation installed. When a predetermined pressure drop is reached, the filter media is to be changed out. The filter housing will normally be drained of solution prior to the removal of the filter media. The polishing filter media will be dried on the vertical lines and bagged out as waste.

Disposal

The filtrate solution will be sampled in Glovebox 3 for plutonium content prior to transfer to building 241-Z or other facility for disposal. The filtrate is circulated back from Glovebox 4 to Glovebox 3 for sampling because Glovebox 3 has a pass through to a conveyor to send the sample to a convenient bag out port outside the magnesium hydroxide process room. Bagging out a sample requires the room to go on mask, which decreases process efficiency. The filtrate will be returned to the precipitators, polishing filters, or blended with filtrate in other filtrate tanks should the plutonium concentration be greater than the filtrate disposal limit. A mass or concentration limit may be established to conform to the Hanford waste tank acceptance limits.

Equipment Description

Glovebox 3 major components and their designed dimensions are summarized in Table 2-1. The glovebox has process inputs of feed solution, magnesium hydroxide and flocculent, control signals for the valves and the pump, electrical power, process water for flushing, and compressed air system to operate the transfer pump and vacuum eductor and process outputs of dried precipitation cake in boats, waste filtrate, feed and filtrate samples, bagged waste, and glovebox air.

Table 2-1. Facility and Equipment Dimensions

Containers	Dimensions
Glovebox	426.72 cm (14 ft) long x 198.12 cm (6.5 ft) tall x 106.68 cm (3.5 ft) depth (inside dimensions)
Precipitator Tanks	TK-001A/B/C, 6.186 in. max ID x 41.5 in. T/T, 20 L
Phase Separator Tank	TK-004, 6.186 in. max ID x 43 in. T/T, 20 L
Vacuum Trap Tank	TK-006, 6.186 in. max ID x 22 in. T/T, 11.1 L
Vacuum Catch Tank	TK-005, 6.186 in. max ID x 12 in. T/T, 5.5 L
Vacuum Filter Basin	FL-001, 17 in. dia. x 2 in. deep
Filter Drying Line	FL-001, 17 in. dia. x ~3/16 in. thick dry plastics
Polishing Filter	FL-002A/B, 6 in. dia. x 15.5 in. duplex (1 operating, 1 standby)
Drip Pan	1' x 1-1/2' x 2 in. or 12 in. x 18 in. x 2 in.
Hot Plate Boat	11 in. x 5 in. x 2.5 in., 2.3 L (nominal inner dimensions)
Furnace Boat	11 in. x 5 in. x 2.5 in., 2.3 L (nominal inner dimensions)
Storage Boat Dock	2.54 cm (1 in.) sq. steel bar welded to glovebox floor
Sweeps Can	0.5 L (geometry: h=d=8.6 cm)
Trash Bag	1 to 2 grams of fissionable material on plastic and equipment
Transfer Pump	P-001, 6.7 in. dia. x 8 in. wide with fluid capacity of 0.15 L

The T/T designator used for the glass pipe tanks above is the length of the cylindrical section. This designation excludes the conical bottom portion of the tank from its length.

2.3 FISSIONABLE MATERIALS DESCRIPTION

Table 2-2 recaps the fissionable material contents for each component under normal operating conditions. The modeled materials under normal, base, and contingency cases are described in Section 5.0. All plutonium and fissionable uranium are modeled as ^{239}Pu . ^{235}U may be substituted for ^{239}Pu on a gram for gram basis as stated in PFP Criticality Prevention Specification CPS-Z165-80010, entitled *General Limits*.

No restrictions are placed on other solids in the precipitate or elements in the solution, except fissionable isotopes, because water is the most effective moderator. Figure 46 in LA-10860-MS shows that water mixed with fissionable material is more reactive than mixing any one of the following with fissionable material: beryllium; beryllium oxide; heavy water; or carbon.

Each of the six glass tanks is surrounded by a cylinder of stiff wire mesh (i.e. hardware cloth) that protects the glass tanks from impact by moving tools or equipment within the glovebox. The wire mesh cylinder is mounted on the outside circumference of flanges at the top and bottom of the tanks. This wire mesh would keep hands, flexible plastic tubing, and other solid reflectors spaced at least 3.8 cm (1.5 in.) from the fissionable solution in the tanks.

Table 2-2. Fissionable & Moderator Material Contents for Normal Operation Condition

Containers	Contents
Glovebox	1/8 in. thick layer of 3 g Pu/cm ³ as PuO ₂ on floor as overly conservative model of possible holdup.
Precipitator Tanks	2.5 kg of plutonium nitrate solution in three tanks.
Phase Separator Tank	1x10 ⁻³ g Pu/L solution fill the tank, 20 L high
Vacuum Trap Tank	1x10 ⁻³ g Pu/L solution fill the tank, 11 L high
Vacuum Catch Tank	1x10 ⁻³ g Pu/L solution fill the tank, 5 L high
Vacuum Filter Basin	2.5 kg Pu in filter as precipitate cake with 50 wt% moisture; 2 in. depth allowed by basin side height.
Filter Drying Lines	No Pu (Minimal Pu during normal operations)*
Polishing Filter	1x10 ⁻³ g Pu/L solution filled
Drip Pan	No Pu (1/8 in. floor accumulation bounds Pu in drip pan)
Furnace Boat on Hot Plate	2.5 kg Pu metal mixed with water and filling a 2.3 L boat.
Boat in Transit	2.5 kg Pu metal mixed with water and filling a 2.3 L boat.
Boats in Boat Dock	Two boats each with 2.5 kg Pu metal mixed with water and filling the 2.3 L boats.
Sweeps Can	1.5 kg at 3 g Pu/cm ³ in PuO ₂
Trash Bag	No Pu (Floor holdup bounding conservatism)
Transfer Pump	Other items bound glovebox fissionable material loading in filtrate
HEPA	1 in. of water at roof conservatively bounds HEPA Pu content

* Plutonium added to filter basin in place of filter medium as a conservatism.

2.4 MISCELLANEOUS EQUIPMENT IN THE GLOVEBOX 3

The glovebox has piping connected to the vacuum catch tank to remove liquid from the floor of Glovebox 3. A piece of tygon tubing attached to piping from the vacuum catch tank is used if needed to recapture leaked liquids. The 1.27 cm (1/2 in.) inside diameter tubing is not modeled explicitly. The tanks are modeled with 0.2794 cm (0.11 in.) larger inside diameter than the maximum tolerance. This conservatism includes the possible effect of the tubing getting close to a tank.

The enclosed pipeway from the blend tanks in Glovebox HC-227S ends with a drain line from the top of the glovebox to a one-liter polybottle on the glovebox floor in a corner. The line and bottle are part of a leak detection system for the interglovebox pipeway. The 1.27 cm (1/2 in.) inside diameter tubing and polybottle are not modeled explicitly. The conservative tank diameter containing extra solids and feed solution is considered to account for the interaction of this tubing also. The three-inch transfer pipeway ends at the top of the glovebox and is remote from a tank. The glovebox air exhaust HEPA filter is located adjacent to the HC-227S pipeway connection to Glovebox 3. The contingency of the external can being brought adjacent to the glovebox is considered to bound the pipeway filling with filtrate. The pump surge tank is not

explicitly modeled, however the vacuum catch and trap tanks are larger in diameter and longer and are filled with filtrate in the base case. The two tanks are considered to bound the pump surge tank volume.

The glovebox is supported by a stand. This stand has cross bracing and small enough openings to preclude casual operator access beneath the glovebox. A brace along the floor would prevent wagon access below the glovebox and may stop a plutonium can from rolling under the glovebox, although a can could be dropped between the bracing and end up under the glovebox. Inclusion of full water reflection at the floor of the glovebox for the base case and contingencies is considered bounding.

The pump in Glovebox HC-227S can pump feed solution to precipitator tanks in Glovebox 3 or to the floor in Glovebox 3 if a vent valve is opened accidentally or two valves are misaligned. If a leak develops in the pump, piping, or process vessels, the filtrate will drip to the floor of a glovebox. There are no other locations that the pump can send the filtrate to that are critically less favorable than the precipitator tanks or the floor of the glovebox. If fissionable solutions and rinse water are being dumped to the glovebox floor, the criticality drain maintains a subcritical depth of liquid on the glovebox floor. The only path to the phase separator tank is thru the vacuum filter basin. All paths require an operator to hold a flexible tubing to direct a fluid stream into the basin. Then, to transfer material from the phase separator tank to the filtrate tanks in Glovebox 4 for disposal, requires a pump and proper alignment of more than two valves. The process piping configuration does not allow transfer of feed solution to Glovebox 4 inadvertently.

A 7.62 cm (3 in.) thick, flat, borated polyethylene shield four feet tall is located between the vacuum filter basin and the nearest precipitator tank. The stainless steel encased shield is about 15.24 cm (6 in.) from both the tank and basin. The absorption of the boron and steel is conservatively left out of the analysis. The reflection of the 12 in. of water modeled at the sides of the glovebox is considered to include the effect of this shield.

Two types of sample connections to process piping allow sampling the filtrate being sent to Glovebox 4 for disposal and the feed solution in each of the precipitator tanks. The samples are collected in 30 mL sample bottles and sent to lab for analysis via the conveyor or the sample bottle sphincter port. The conservatism of tank diameter, the 1/8" floor layer of plutonium oxide, and the reflection around the glovebox are considered to cover movement of up to 50 mL sample bottles around the glovebox.

Glovebox 5, the pass through between Glovebox 3 and conveyor HC-3, begins its first section at about 8 in. above the glovebox floor oriented perpendicular to the long glovebox axis. In about a foot, the connection makes a left turn to the conveyor about two feet away with another 8 in. step. A boat located around the corner would not be expected to get back into the glovebox in an earthquake, but one in the first section could.

The vacuum filter drying lines are located along the center line of the glovebox behind the vacuum filter basin. Two loops of thick monofilament are stretched between pulleys at the top and bottom of the glovebox. This arrangement allows the used filters to be attached at the

operating elevation and then raise above the working elevation. The filters remain over the drip pan on the floor of the glovebox.

2.5 CONTAINERS

Gloveboxes 3 and 5 have boats, sample bottles, pipeway leak detection bottle, and trash bundles. The boats have inside dimensions of 10 7/8 in. long, 5 in. wide, and 2 7/16 in. high. It has two 5/16 in. diameter holes at each end whose edge is 1 3/4 in. from the outside bottom of the boat. A boat may be used to move the sample bottles in and out of the glovebox. The sample bottles are expected to have a volume of 30 mL. Operators expect to need a dozen sample bottles in the glovebox. The nominal one liter leak detection bottle is located in a corner of the glovebox near the tanks. A flexible plastic tube connects the tap on the pipeway from HC-227S to the leak detection bottle. Trash bundles remove surplus material from the glovebox. They are expected to contain ice cream cartons that brought in the magnesium hydroxide and flocculent, the dried vacuum basin filters, and dried sock filters from the polishing filter. These items are projected to carry only a few grams of plutonium.

Figure 2-1. Magnesium Hydroxide Process Schematic Drawing

3.0 LIMITS AND CONTROLS

This section identifies the controlled parameters and their associated limits upon which nuclear criticality safety depends. The dimensions required for safe handling of fissionable material are listed in the engineered safety features section.

3.1 LIMITS

- Maximum total mass of plutonium in the three precipitation tanks is 2.5 kg, which may be met by controlling the volume and concentration of the feed solution.
- Maximum plutonium concentration in the feed solution is 100 g Pu/L.
- Maximum mass of plutonium per unit mass (batch) is 2.5 kg.
- Maximum of one (1) batch in vacuum filter basin.
- Maximum of one (1) batch per boat and each upright boat is considered to contain a batch.
- Maximum number of boats as containers allowed in Glovebox 3 is 4. One boat of the four boats may be anywhere except within 25.4 cm (10 in.) of the tanks in Glovebox 3. The remaining boats are to be in the boat dock (maximum of two (2) boats), on the hot plate [maximum of one (1) boat], or adjacent to the vacuum filter basin [maximum of one (1) boat].
- Maximum number of containers allowed in Glovebox 5 is one (1) boat and all other containers allowed in Glovebox 3.
- Maximum uranium enrichment is 50 wt % U-235.
- No boat or container of fissionable material is to be brought into Glovebox 3 or 5 that did not originate in Glovebox 3.
- Maximum volume of fissionable material allowed in boats is 2.3 L.
- Twelve fissionable material bearing sample bottles of up to 50 mL and any number of empty, closed sample bottles are allowed anywhere in the glovebox. Sample bottles may be moved in a boat or in a container of up to a nominal 1 L volume.
- One sweeps container of nominal 0.5 L volume is allowed.
- One leak detection bottle of nominal 1 L volume is allowed.
- Three 250 mL nominal containers with precipitator solution are allowed for pH determination.
- A total of four (4) vacuum basin filters and/or sock filters from the polishing filters are allowed on the drying lines and in Glovebox 3.
- Drip pan below the vacuum filter drying rack is limited to 5.08 cm (2.0 in.) depth.

3.2 PROCESS CONTROLS

- Noticeable accumulation of spilled fissionable material on the glovebox floor or filter drip pan shall be cleaned up as soon as practical.
- Operations is to make two independent determinations of the fissionable material concentration in each batch of feed solution sent to Glovebox 3.

- Boats are prohibited to be stored under the precipitator and other tanks or in Glovebox 5 before the corner or within 25.4 cm (10 in.) of the HC-3 conveyor.
- Heaping in the furnace boats or vacuum filter basin is to be smoothed below the side wall height as soon as practical.
- Damp rags (maximum of 6 square feet total area) may be present in the glovebox for cleaning purposes.
- Non-fissionable material bearing boats and containers are to be made non-containers, turned upside down, or kept 25.4 (10 in.) edge-to edge from other fissionable material.
- No stacking of plutonium bearing containers or boats is allowed.
- HEPA prefilter change out is allowed only when tanks are empty and all fissionable materials are removed from the glovebox except holdup.
- Polishing filters with more trapped precipitate than normal are to be changed out under the guidance of the PFP Criticality Safety Representative.
- No storage of fissionable or reflecting materials below the glovebox floor is allowed.
- Criticality drain is to be visually inspected periodically to be unobstructed to the flow of water.
- No pressurized plant water system piping system piping is allowed in Glovebox 3.
- Gloveboxes 3 and 5 are to be Fire Fighting Category C.

3.3 ENGINEERED SAFETY FEATURES

- Glovebox is seismically qualified to remain standing in a DBE (Design Basis Earthquake).
- Glovebox 3 has a criticality drain that limits introduced water to a 7.62 cm (3.0 in.) depth.
- Minimum spacing between the six tanks is 25.4 cm (10 in.) glass edge-to-edge. Three precipitation tanks are to be in a line.
- Tanks are limited to 111.76 cm (44 in.) inside height and a maximum inside diameter of 15.748 cm (6.2 in.).
- The vacuum filter basin is restricted to have a maximum depth of 7.874 cm (3.1 in.), 5.334 cm (2.1 in.) above and 2.54 cm (1.0 in.) below the perforated filter support plate, and to a maximum inside diameter of 43.434 cm (17.1 in.).

4.0 METHODOLOGY

4.1 MCNP4B VERIFICATION & VALIDATION

The Monte Carlo Code MCNP Version 4B, was certified (Schwinkendorf 1998) and validated (Erickson 1998 and Lan 1999) for plutonium such as the operation in this glovebox. Room temperature cross sections were used for the MCNP calculations. Some experimental data indicate that Pu-239 may have a very small positive (on the order of 10^{-5} to 10^{-6} $\Delta k/k/^{\circ}\text{C}$) reactivity response to increasing temperature (Hummel 1978). This is insignificant compared with the typical statistical uncertainty of 0.002 for the MCNP calculations. Only under normal conditions are the hot plate boats heated to 550°F on the hot plate. The heating on the hot plate drives off water, reducing the H/X ratio. The heating also slightly expands the physical dimensions for the fissionable material according to the temperature coefficient of expansion. Both of these phenomena decrease reactivity, but were not included in the analyses. Therefore, room temperature cross sections and material densities are the most appropriate to compare with safety limits.

A summary of the validation of MCNP4B is included in Appendix B, MCNP4B Computer Code Validation, which determines a maximum allowable k_{eff} value of 0.942 for non-metal and 0.932 for metal system calculations. These values are for calculations with statistical uncertainties of $\leq \pm 0.002$ and assure subcriticality with an acceptable margin, including the uncertainties in the analytical methods and benchmark experimental data.

4.2 SUB-CRITICAL LIMIT

For the purpose of this report, the principal criticality prevention criterion or parameter is that the effective neutron multiplication (or criticality) factor (k_{eff}) shall not exceed 0.95 (i.e., $k_{\text{eff}} \leq 0.95$) for all permitted normal configurations of materials, containers, etc., and for any credible off-normal event. This criterion is based on implementing the applicable DOE Order 5480.24 (DOE 1992), ANSI standards (ANSI/ANS-8.1 1998), and HNF-PROs (FDH 1997, FDH 1997a, and FDH 1997b). The subcriticality is used to judge the acceptability of a calculated k_{eff} value for fissionable material configuration. This criterion must account for the bias inherent in the code and cross sections used, any uncertainties in the physical problem being analyzed, and the uncertainties in both the bias determination (the experimental basis) and the calculational methods.

4.3 APPLICATION OF DOUBLE CONTINGENCY PRINCIPLE

This analysis must meet the requirements of HNF-PRO-334, *Criticality Safety General Requirements* (FDH 1997), HNF-PRO-537, *Criticality Safety Control of Fissionable Material* (FDH 1997a), and HNF-PRO-539, *Criticality Safety Evaluations* (FDH 1997b). HNF-PRO-539 states that for all new operations and changes pertinent to criticality safety issues in existing operations, the CSER is required to demonstrate that there is an acceptable margin of

subcriticality for all normal and credible abnormal conditions. To demonstrate the Double Contingency Principle is satisfied, this CSER must show that there are sufficient factors of safety in the operation of Glovebox 4 such that at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality accident is possible.

4.4 HAZARDS ASSESSMENT

Identification of the contingencies for the operation described in Section 2 and evaluated in Section 5 used a hazards assessment technique called a hazard assessment. The goal of this effort is to identify deviations from the planned operation that may pose a challenge to criticality safety. Analysis is done, as necessary to demonstrate that each identified condition is adequately subcritical.

In a hazard assessment, an interdisciplinary team uses a disciplined, systematic approach to identify hazards and deviations that could lead to undesirable consequences. Because the criticality safety concerns usually arise from deviations from the process design, an experienced team leader systematically guides the team through the planned operation. Off-normal events are identified and separated into likely and unlikely to happen during the lifetime of the operation. The likely events become part of the base case and unlikely events are the contingencies of Section 5. The details of these assessment results are presented in Appendix D.

4.5 ASSUMPTIONS

The following assumptions were made in carrying out the analysis in the CSER.

- Fissionable material is all Pu-239.
- The filter is conservatively left out of the filter basin in determining the depth of material in the vacuum filter basin.
- 2.25 L used for nominal 11 in. x 5 in. x 2.5 in. furnace boat.
- The hot plate is to be covered by a borated polyethylene and steel encasement to shield operators from radiation. The shield increases the neutron reflection to the boat. An analysis of the shielding is documented in Appendix G. The hot plate alone (case nca12) has a k_{eff} comparable to that of the glovebox (cases nca and ncb) when boron is not modeled in the polyethylene. When 5% boron is included (case ncbbo) in the polyethylene, the reactivity drops substantially. The neutron absorber is not included in either the base case or the contingency analyses.
- The concentration for the maximum reactivity of plutonium nitrate solution is 250 g Pu/L (Carter 1968).
- It is not considered credible to have plutonium nitrate spray into the glovebox from the vacuum eductor during normal operation or during a seismic event. Solution would have to over flow two tanks in series to reach the eductor.
- A 15.2 cm (6 in.) depth of solids in the precipitator tanks is the maximum credible. If a full tank of 20 L of 450 g Pu/L precipitated at 3 g Pu/cm³, the depth would be less than 15.2 cm (6 in.). Multiple batches of precipitate in the tanks is not considered credible because if the

precipitate did not flow out it would block the filtrate and there would not be room to bring in more feed solution to process.

- It is not credible to have a precipitate with a density greater than 3 g Pu/cm^3 . Experimental data found that the plutonium hydroxide precipitate density from the magnesium hydroxide process is normally about 0.2 g Pu/cm^3 as reported in Appendix H.
- The number of gloves and screening around tanks keeps operator hands to 1 in. of reflection along a 6 in. length of tank at a time.
- Rinse water line delivers less than 6 gpm.
- The neutron absorption of the boron in the glass tanks and in the hot plate shield and of the metals in the boats is not included in the model. Leaving the absorbers out of the model is part of the defense in depth of a conservative analysis.
- A sock filter in a polishing filter accumulates a nominal 1/8 in. thickness of solids before the pressure drop increases to block fluids being pumped thru the filters.

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5.0 EVALUATION AND ANALYSIS

5.1 NORMAL CASE

Table 5-1-1 lists the dimensions of modeled equipment. These dimensions are conservative compared to the design dimensions listed in Table 2-1 to cover tolerances and corrosion. Figure E-1 shows the top view of the glovebox and equipment arrangement. Figure E-2 shows the component names and equipment numbers used in the Process Flow Diagram (H-2-829761). Based on the fissionable material description shown in Table 2-2 of Section 2.3, the calculated mixture densities and material weight fractions are shown in Table 5-1-2. The table also lists the H/X ratios of the materials in the containers and tanks. The reflector materials and their modeling locations are listed in Table 5-1-3. These three basic parameters, dimensions, materials, and reflectors, are used to develop the MCNP inputs files reproduced in Appendix C.

Table 5-1-1. Modeled Facility and Equipment Dimensions for All Conditions

Containers	Dimensions
Glovebox	426.7 cm x 198.1 cm x 106.7 cm (14 ft x 6.5 ft x 3.5 ft or 168 in. x 78 in. x 42 in.), seismically qualified
Precipitator Tanks	TK-001A/B/C, 16 cm (6.3 in.) dia. x 91.4 cm (36 in.) T/T, 20.1 L
Phase Separator Tank	TK-004, 16 cm (6.3 in.) dia. x 91.4 cm (36 in.) T/T, 20.1 L
Vacuum Trap Tank	TK-006, 16 cm (6.3 in.) dia. x 55.9 cm (22 in.) T/T, 11.2 L
Vacuum Catch Tank	TK-005, 16 cm (6.3 in.) dia. x 30.5 cm (12 in.) T/T, 5.6 L
Vacuum Filter Basin	FL-001, 44.5 cm (17.5 in.) dia. x 5.3 cm (2.1 in.) deep sludge
Drying Filter	FL-001, 44.5 cm (17.5 in.) dia. x ~0.5 cm (3/16 in.) made of thick, dry plastic
Polishing Filter	FL-002A/B, 15.2 cm (6 in.) dia. x 39.4 cm (15.5 in.) (1 operating, 1 standby)
Drip Pan	30.5 cm x 45.7 cm x 5.1 cm (1 ft x 1-1/2 ft x 2 in. or 12 in. x 18 in. x 2.1 in.)
Hot Plate Boat	27.9 cm x 12.7 cm x 6.4 cm (11 in. x 5 in. x 2.5 in.), 2.3 L
Boat	27.9 cm x 12.7 cm x 6.4 cm (11 in. x 5 in. x 2.5 in.), 2.3 L
Boat at Boat Dock	27.9 cm x 12.7 cm x 6.4 cm (11 in. x 5 in. x 2.5 in.), 2.3 L,
Sweeps Can	0.5 L (geometry: h=d=8.6 cm)
Trash Bag	0.13 cm (1/8 in.) Pu holdup on floor and 2.54 cm (1 in.) of water around containers conservatively bound Pu and plastic content
Transfer Pump	P-001, 17 cm (6.7 in.) dia. x 20.3 cm (8 in.) wide
Sample Bottle	Up to 50 mL
HEPA	2.54 cm (1 in.) of water around containers conservatively bounds

The dimensions of the normal case are those used for the base and contingency cases. Comparing Tables 2-1 and 5-1-1 shows that the glovebox is modeled at its actual size while the tanks and pump are conservatively modeled. The six tanks are modeled at a diameter of 6.3 in., which is larger than the actual 6.186 in. maximum inside diameter of the glass tank. The volume of the tank was modeled at 20.1 L, an increase over the nominal tank volume of 20.0 L and the tank height was adjusted to fit the conservative diameter and volume. The shorter, larger diameter is a more conservative model of the tank volume.

The pump is modeled as a 6 in. diameter cylinder 8 in. long. This volume is much greater than the pump volume. The odd shaped pump is fabricated of $\frac{3}{4}$ -in. piping around a 4 in. diameter central cylinder about 4 in. long with one inch long cones on each end of the cylinder. The surge tank connected to the pump is 5.25 in. diameter and 10.5 in. long. Half the surge tank would have air and the other half fluid from the pump. The volume of the pump model covers both the pump and surge tank volume. The added diameter of the tanks and pump covers the affect of the piping in the glovebox for the normal case. The tanks are modeled spaced at least an inch closer than as-built as shown in Appendix F.

Table 5-1-2. Mixture Density and Material Weight Fraction for Normal Operation Condition

Containers	ρ_{mix}	Wt. Frac. of H	Wt. Frac. of O	Wt. Frac. of Pu	H/X
Glovebox (1/8" holdup)	4.104800	0.019040	0.250110	0.730850	6.23
Precipitator Tanks	1.047500	0.105800	0.846500	0.047700	530.00
Phase Separator Tank	1.000001	0.111111	0.888888	0.000001	27,750.00
Vacuum Trap Tank	1.000001	0.111111	0.888888	0.000001	27,750.00
Vacuum Catch Tank	1.000001	0.111111	0.888888	0.000001	27,750.00
Vacuum Filter Basin	1.903890	0.055600	0.444400	0.500000	27.00
Drying Filter	1.000000	0.111111	0.888889	0.000000	∞
Polishing Filter	1.000000	0.111111	0.888889	0.000000	∞
Drip Pan	1.000000	0.111111	0.888889	0.000000	∞
Hot Plate Boat	1.758500	0.060600	0.485100	0.454300	32.00
Furnace Boat	1.758500	0.060600	0.485100	0.454300	32.00
Storage Boat Rack	1.758500	0.060600	0.485100	0.454300	32.00
Sweeps Can	3.848640	0.024500	0.196000	0.779500	7.50
Trash Bag	No Pu (floor holdup bounding conservatism)				
Transfer Pump	1.000000	0.111111	0.888889	0.000000	∞
HEPA	1 in. water at roof conservatively bounds HEPA Pu content				

Table 5-1-3. Reflector Material Contents for Normal Operation Condition

Containers	Contents
Glovebox	N/A
Precipitator Tanks	N/A
Phase Separator Tank	N/A
Vacuum Trap Tank	N/A
Vacuum Catch Tank	N/A
Vacuum Filter Basin	N/A
Drying Filter	N/A
Polishing Filter	Filled with water
Drip Pan	Filled with water
Hot Plate Boat	N/A
Furnace Boat	
Storage Boat Rack	
Sweeps Can	N/A
Trash Bag	N/A
Transfer Pump	N/A
HEPA	1 in. of water at top of glovebox conservatively bounds

The normal case includes six batches of 2.5 kg Pu material: one in the precipitation tanks, one in the basin and another in the adjacent boat, one in a boat on the hotplate, and one in each of the two boats sitting at the boat dock. An 1/8 in. of 3 g Pu/cm³ as plutonium oxide is modeled on the entire glovebox floor. The calculational model of the glovebox and components uses compositions from Section 2 and the tables above. The k_{eff} for this case is 0.7900 ± 0.0005 (case nca). Reactivity of various components in the glovebox is provided in Appendix G.

5.2 BASE CASES

5.2.1 PRIMARY BASE CASE

The base case includes the normal as well as the abnormal but anticipated process conditions. The controlled parameters specified in Table 1-1, Summary of Base Case Limits, are used to model each process component as shown in Table 5-2-1 through Table 5-2-3. Two dimensional plots of the base case model having material numbers printed out for each component are shown in Appendix E. Figures E-3 to E-7 are the Y-Z side view plots X distance along the length of the glovebox. Figures E-8 to E-10 are the X-Z front views plots Y distance along the depth of the glovebox. Figures E-11 to E-15 are the X-Y top view plots Z distance along the height of the glovebox. The numbers on the figures designate the material as explained in the table at the beginning of Appendix E.

The precipitator tanks are modeled with 100 g Pu/L plutonium nitrate solution that bounds the actual operation. The 100 g Pu/L is conservative relative to the normal design operating conditions of 50 g Pu/L. Figure III.A.4(100)-1 in ARH-600 (Carter 1968) shows that the most reactive concentration of plutonium nitrate over the range of 0 to 450 g Pu/L (maximum credible plutonium nitrate solution at PFP) in a cylinder is 250 g Pu/L. This concentration of plutonium nitrate solution will be used as a contingency in Section 5.3.1. The 450 g Pu/L is an upper bound on plutonium nitrate solution because PUREX and PFP had that as the limit on plutonium solution concentration. Any solutions above that concentration would have been diluted to be within that allowable.

The bottom of the precipitation tanks have 3 in. long conical transition fittings between the bottom of the glass cylindrical tank and the process piping. Two flanges are used to make a seal at this transition. Because the flanges and fittings are stainless steel, the bottom 3 to 4 in. are not visible from the side. Operators may not know if there are solids in the bottom of the tanks. To allow operations without inspecting the bottom 4 in. of the tanks, the base case includes solids in the bottom of the tanks. The base case could have used 5 in. of low density plutonium oxide. However, the model used covers the upset condition of precipitate from a full 20 L tank filled with 450 g Pu/L plutonium nitrate solution at a highly conservative density of 3 g Pu/cm³. Because 450 g Pu/L is the maximum plutonium concentration allowed at PUREX and PFP, this is the maximum plutonium possible for a filled tank. At 3 g Pu/cm³, the 9 kg of plutonium occupies 6 in. of the 6.3 in. diameter glass tank. Using this high density solids and full diameter tank, the tank model is highly conservative and would accommodate any plutonium solution and precipitate without exceeding double contingency limits. The normal 600 grams to be precipitated in a precipitation tank would occupy 4 in. at an expected 0.3 g Pu/cm³. At 3 g Pu/cm³, the 600 grams would only occupy 0.39 in. Using 6 in. of 3 g Pu/cm³ is conservative.

The plutonium in the solution is precipitated by addition of magnesium hydroxide and agitated to promote a complete chemical reaction. To analyze the tanks loaded with plutonium precipitate, 15.2 cm (6 in.) of plutonium at 3 g Pu/cm³ as PuO₂ is modeled at the bottom of the three precipitator tanks with 100 g/L plutonium nitrate solution filling up the rest of the tank. For the base case, all other tanks (phase separator, vacuum trap, and vacuum catch tanks) are also filled with a concentration of Pu(NO₃)₄ solution of 1 g Pu/L, bounding the 10⁻³ g Pu/L expected concentration.

The model does not include any magnesium even though it may be present as hydroxide, nitride, or oxide. Magnesium has a low absorption cross section, but not as low as oxygen. Hydrogen is a more effective moderator. Figure 46 in LA-10860-MS shows that for useful concentrations of fissionable material, water is a more reactive material to mix with fissionable material than beryllium, heavy water, or carbon. The fissionable material is modeled with water filling out the solution, precipitate, or filter cake rather than including any magnesium that would displace water.

The base case for the vacuum filter basin has 2.75 kg plutonium containing 50 wt% moisture as a layer above the perforated plate that holds the filter and 1.77 kg of plutonium below the filter plate as 1 in. of 450 g Pu/L solution (highest possible concentration at PFP).

Any plutonium residue dripping from the filters on the drying rack into the drip pan is modeled by the 1/8 in. thick layer of 3 g Pu/cm³ as PuO₂ holdup on glovebox floor. The polishing filters are modeled full of 1 g Pu/L solution.

Trash bags are conservatively bounded by the 1/8 in. thick layer of 3 g Pu/cm³ as PuO₂ on the floor and the water reflector around containers and the glovebox. Table 5-2-2 lists each item's mixture densities and material weight fractions input to MCNP for the base case.

The base case does not include the unlikely event of an overflow along the vacuum system or solution misrouted. This condition is evaluated as a contingency in Section 5.3.1 where the phase separator tank (20 L), vacuum trap tank (11 L), vacuum catch tank (5.6 L), and polishing filters are all modeled as filled with 250 g Pu/L solution.

No limit on holdup depth is included in the limits because for this system, an 1/8 in. layer of plutonium on the entire glovebox floor is equal to 43.37 kg of plutonium, an incredible amount, and because cleanup of spills is required.

The base case models a boat with 2.75 kg plutonium so that double contingency is demonstrated for a small error (<0.25 kg Pu) in mass. In addition, a 2.3 L boat containing 2.75 kg of plutonium at Pu oxide density mixed with water is placed under a precipitation tank, an abnormal but anticipated event. Trash bags are conservatively bounded by the 1/8 in. thick layer of 3 g Pu/cm³ as PuO₂ on the floor. Table 5-2-2 lists each item's mixture densities and material weight fractions input to MCNP for the base cases.

The base case models five boats with 2.75 kg of plutonium in each boat. Four boats are located at the four normal stations for boats: two boats in the boat dock; one boat on the hot plate; and one boat adjacent to the vacuum filter basin. In this base case model, both the basin and adjacent boats have 2.75 kg Pu. The basin and associated boat are limited to 2.75 kg each. A fifth boat is placed under the precipitation tanks to cover the anticipated upset condition of a boat placed on the floor of the solution process area of the glovebox. It also covers the case of one boat stored in the straight segment of Glovebox 5 connection to conveyor HC-3 from Glovebox 3.

Because of the tight spacing of the boat dock, drip pan, and filter drying line supports, and hot plate cover supports, a third boat at the boat dock is not anticipated and that case is treated as a contingency in Section 5.3.

The reflection that a scale, hot plate, struts, piping, and other equipment may contribute is bounded by water surrounding the glovebox. The HEPA filter, with up to 10 g Pu/ft³, is bounded by the 1/8 in. of plutonium holdup on the glovebox floor and by 1 in. of water at the level of the roof of the glovebox. To simulate operators standing around the glovebox and other potential neutron reflection materials, 12 in. of water surrounds the sides of the glovebox. To account for operators reaching under the glovebox, 6 in. of water is modeled below the glovebox. And 1 in. of water above the glovebox models nominal room reflection. Table 5-2-3 has other details of reflector modeling. The combination of normal conditions allowed by limits and anticipated abnormal conditions are used to evaluate the criticality safety of normal operations in the

glovebox as the base case. The calculated k_{eff} for this base case, bc, is 0.8825 ± 0.0005 . Sensitivity of this k_{eff} to various components in the glovebox is presented in Appendix G.

Table 5-2-1. Fissionable & Moderator Material Contents for Base Case

Containers	Contents
Glovebox	1/8 in. thick layer of 3 g Pu/cm ³ as PuO ₂ on floor modeling glovebox holdup. It is under the boats and other equipment.
Precipitator Tanks	(a) The tank contents are simulated by 100 g Pu/L solution of plutonium nitrate mixed with water, plus (b) 6 in. of Pu solids (3 g Pu/cm ³ as PuO ₂) at bottom of the three precipitation tanks
Phase Separator Tank	The tank contents are simulated by 1 g Pu/L solution of plutonium nitrate mixed with water and filling the 20.1 L tank completely
Vacuum Trap Tank	The tank contents are simulated by 1 g Pu/L solution of plutonium nitrate mixed with water and filling the 11.2 L tank completely
Vacuum Catch Tank	The tank contents are simulated by 1 g Pu/L solution of plutonium nitrate mixed with water and filling the 5.6 L tank completely
Vacuum Filter Basin	(a) 2.75 kg Pu in 50 wt% moisture precipitate cake on filter with max. of 2.1 in. accumulation depth allowed above the perforated filter support plate, plus (b) 1 in. of 450 g Pu/L solution below perforated plate
Drying Filter	Bounded by 1/8 in. holdup on glovebox floor
Polishing Filter	1 g Pu /L solution
Drip Pan	Simulated by 1 g Pu/L solution of plutonium nitrate mixed with water and filling the pan
Boat on Hot Plate	2.75 kg Pu metal mixed with water and filling a 2.3 L boat.
Boat	2.75 kg Pu metal mixed with water and filling a 2.3 L boat.
Boat Dock	2.75 kg Pu metal mixed with water and filling two 2.3 L boats.
Boat in tank section of glovebox	2.75 kg Pu metal mixed with water and filling a 2.3 L boat located under center precipitation tank.
Sweeps Can	1.5 kg at 3 g Pu/cm ³ as Pu in water at an H/X of 7.5, which bounds an H/X of 20 limit for the sweeps can Pu as oxide.
Trash Bag	1/8 in. thick layer of 3 g Pu/cm ³ as PuO ₂ on floor conservatively bounds trash bag
Transfer Pump	1/8 in. thick layer of 3 g Pu/cm ³ as PuO ₂ on floor conservatively bounds transfer pump
Sample Bottles	Excess tanks diameter bounds sample bottles
HEPA	Floor holdup plutonium and 1 in. of water at roof conservatively bounds mass and reflection of filter

Table 5-2-2. Mixture Density and Material Weight Fraction for Base Case

Containers	ρ_{mix}	Wt. Frac.* of H	Wt. Frac. of O	Wt. Frac. of Pu	H/X
Glovebox holdup	4.101430	0.019040	0.250110	0.730850	6.23
Precipitator Tanks (a) *	1.158000	0.092000	0.802000	0.086000	530.00
Precipitator Tanks (b)	4.101430	0.019040	0.250110	0.730850	6.23
Phase Separator Tank	1.001000	0.111000	0.888000	0.001000	26517.00
Vacuum Trap Tank	1.001000	0.111000	0.888000	0.001000	26517.00
Vacuum Catch Tank	1.001000	0.111000	0.888000	0.001000	26517.00
Vacuum Filter Basin (a)	1.903890	0.055600	0.444400	0.500000	27.00
Vacuum Filter Basin (b)	1.427280	0.076079	0.608635	0.315286	57.00
Drying Filter	Bounded By 1/8" of Gloveboxb holdup				
Polishing Filter	1.001000	0.111000	0.888000	0.001000	26517.00
Drip Pan	1.001000	0.111000	0.888000	0.001000	26517.00
Hot Plate Boat	2.263000	0.043000	0.418000	0.539000	19.00
Boat	2.263000	0.043000	0.418000	0.539000	19.00
Boat Dock	2.263000	0.043000	0.418000	0.539000	19.00
Transition Boat	2.263000	0.043000	0.418000	0.539000	19.00
Sweeps Can	3.848640	0.024500	0.196000	0.779500	7.50
Trash Bags	Bounded by 1/8 in. of glovebox holdup				
Transfer Pump	Bounded by 1/8 in. of glovebox holdup				
Sample Bottles	Excess tanks diameter bounds sample bottles				
HEPA	Bounded by Pu holdup and 1 in. water at roof				

* Wt. Frac. of N is 0.02

Table 5-2-3. Reflector Material Contents for Base Case

Containers	Contents
Glovebox	12 in. of water around sides accounts for operators; 6 in. of water below accounts for operator reaching under glovebox; 1 in. of water above models nominal room reflection.
Precipitator Tank	1 in. of water reflector around a 6 in. length of each tank accounts for operator hands, rags, piping, equipment and trash
Phase Separator Tank	
Vacuum Trap Tank	
Vacuum Catch Tank	
Vacuum Filter Basin	1 in. of water reflector around each filter accounts for operator hands, rags, piping, equipment and trash.
Drying Filter	
Polishing Filter	
Drip Pan	Bounded by 6 in. of water under glovebox and 5.08 cm (2 in.) of water filling the drip pan

Containers	Contents
Boat by vacuum filter	1 in. of water reflector around each boat accounts for operator hands, rags, piping, equipment and trash
Boat on Hot Plate	
Storage Boat Dock	
Sweeps Can	1 in. of water reflector around can accounts for operator hands, rags, piping, equipment and trash
Trash Bag	1 in. of water around containers conservatively bounds
Transfer Pump	Bounded by water around glovebox
Sample Bottles	Excess tanks diameter bounds sample bottles
HEPA	Pu holdup and 1 in. of water at roof conservatively bounds

5.2.2 ALTERNATE BASE CASE

Only four boats containing fissionable material are allowed in Glovebox 3. Only one boat is allowed to be stored or left unattended at the basin and at the hot plate and only two at the boat dock. Since one boat is allowed to be in transit without spacing, the alternate base case shows that the k_{eff} for three boats is within allowables. Since the space at the hot plate end of the glovebox is crowded with equipment and structure, a boat in transit is allowed to be close to the basin containing a 2.75 kg batch of plutonium in the basin and one batch in an adjacent boat or to the boat dock with two boats each containing a batch. To preclude having three batches normally within 25.4 cm (10 in.) of each other, the boat in transit is not allowed to be stored at the basin, hot plate, or boat dock. This restriction and the restriction that only four boats are allowed in Glovebox 3 makes an accidental grouping of four boats unlikely.

No specific cases were run for the alternate base case of three batches of 2.75 kg of plutonium grouped together. Six contingency cases will be used to show that the three batch aggregation is acceptable. Case cc3 listed in Table 5-3-1 shows that two adjacent boats with one double batched has an acceptable k_{eff} of 0.8860 ± 0.0005 . Case cc4 stacks a third boat on top of two below violating stacking, but it bounds three adjacent boats. Table 5-3-1 lists the k_{eff} for this case as an acceptable 0.8871 ± 0.0006 . The case cc8 double batches the vacuum filter basin with 5.5 kg of plutonium as described in Section 5.3.8 of this CSER. A third batch is in the adjacent boat. This three batch assembly has a k_{eff} of 0.8741 ± 0.0005 . Also described in Section 5.3.8 is case ccs that filled the 2.1 in. deep upper portion of the basin with 14.9 kg at 2 g Pu/cm³ and had a boat adjacent to the basin. This case has 6 batches of 2.75 kg of plutonium. Table 5-3-1 list the k_{eff} as 0.9352. If four boats are arranged as a wall between the boat dock and the corner of the glovebox against the side of the glovebox as shown in Figure E-16, a k_{eff} of 0.8921 ± 0.0005 results. In this case cc10, the boats are head to head and stacked two high. Each boat has 2.75 kg plutonium in water filling the boat volume. The two boats on the top are covered by an inch of water. The boats at the boat dock, hot plate, and basin, are modeled as water since having eight batches is not credible. The batch in the tanks and in the vacuum basin were retained. The eighth inch of 3 g Pu/cm³ on the glovebox floor is also retained in this model. A sixth case, cc103, has the same arrangement of the glovebox as case ccs except the four boats are arranged in a two by two array with the long sides adjacent. This case is described in Section 5.3.3. The k_{eff} is 0.9312 ± 0.0005 . This case, cc103, bounds four boats arranged in a plane.

Glovebox 3 has numerous containers that are allowed to move about the glovebox. The contingency case cwcc7 is being used to show that the worst case grouping of these containers is within allowables. The worst case arrangement has all the containers grouped around the vacuum filter basin because the basin adds the most volume to the model. None of the containers are stacked, that would violate a limit. This model explicitly incorporates the mass and volume of: (1) the vacuum filter basin with a 2.75 kg batch of plutonium; (2) two boats with a batch each (actually three boats for the contingency case cwcc7); (3) the ½ L sweeps can with 1.5 kg of plutonium; (4) the 1 L leak detection bottle filled with 250 g Pu/L feed; (5) three 250 mL pH sample containers filled with 250 g Pu/L feed. The twelve sample bottles of up to 50 mL each filled with 3 g Pu/L filtrate are considered bounded by the extra mass and volume in the vacuum filter basin modeled with a larger than the design diameter and the reflection modeled around model and around the glovebox. The material in the non-boat containers are about 3 in. tall, except the 1 L leak detection bottle. It too is modeled as 3.1 in. tall to be as close to the rest of the fissionable material as possible. The material in the basin is modeled in the upper portion above the perforated plate with a depth of 2.1 in. which is consistent with the height to which boats can hold material. The model geometry and materials are described in Section 5.3.4. The k_{eff} for the case cwcc7 is 0.8864 ± 0.0005 . This contingency case shows that an aggregation of four batches and the containers that can move about the glovebox are within the allowable limit of 0.942

5.3 CONTINGENCIES

A contingency is defined as an unlikely event, process upset condition, or natural phenomena. The CSER shows in the contingency analysis that a contingent event in singular occurrence will not result in exceeding the allowable k_{eff} for the critical system being analyzed and that the Double Contingency Principle is met. The Double Contingency Principle requires that two independent, unlikely occurrences are necessary to exceed the allowable k_{eff} or other specified limit for the critical system being analyzed before a criticality is possible. Table 5-3-1 lists the postulated unlikely, independent, non-concurrent, off-normal events (contingencies) and the analysis results. Each event is assumed to occur upon adding a contingency condition to the base case (bc) as configured in the previous section.

Table 5-3-1. Contingencies for Glovebox 3

Case	Description *	k_{eff}	One Sigma
cc1	250 g/L Pu nitrate in precipitation tanks with 15.2 cm of Pu oxide solids in tank bottom at 3 g Pu/cm ³	0.8884	0.0005
cc2c	Vacuum tanks/phase separator tank/precipitator tanks filled with 250 g/L	0.8932	0.0005
cc3	One over batched boat in boat dock	0.8860	0.0005
cc4	Third boat stacked on top of two boats in boat dock	0.8871	0.0006
cc103	2 x 2 boat array in glovebox corner	0.9312	0.0005
cc5	Seismic event with broken tanks and sprinkler water to 3.25 in. depth on floor of glovebox.	0.9359	0.0005

Case	Description *	k_{eff}	One Sigma
cc1121	Interspersed moderation at full water density without glass tanks breaking.	0.9410	0.0014
cwcc7	Aggregate of containers	0.8864	0.0005
cc7	Conservative 4.5 kg BTC against side of glovebox	0.9105	0.0006
cc8	Double batched vacuum filter basin having 5.5 kg Pu as metal mixed with water filling upper basin	0.8741	0.0005
ncs2	Spacing between tanks reduced	0.9207	0.0014
ccs	Upper vacuum filter basin filled with 2 g Pu/cm ³ PuO ₂	0.9352	0.0005

* Each contingency model uses the base case bc with the changes described in this table.

Precipitate tanks were evaluated for the unlikely event of filling with the optimum reactivity, 250 g Pu/L Pu(NO₃)₄ solution (cc1). Vacuum and phase separator tanks were evaluated for the unlikely occurrence of precipitate tank contents finding their way to these tanks (cc2c). One of the boats in the boat dock was double batched (ccs3). A boat was stacked on top of two boats already at the boat dock (cc4). This case cc103 bounds an extra boat. A fissionable material container was brought up to the side of the glovebox (cc7) and the filter basin was double-batched with solids (cc8). Case ccs, a contingency case, and case ccs1 (an incredible case, see Section 5.3.8) show that the vacuum filter basin is a geometrically favorable container. The vacuum filter basin rim is 2.1 in. above the perforated plate that holds the filter. This basin is to hold the precipitate filtered out of the filtrate. There is a maximum of a one-inch high space below the perforated plate that can be filled with plutonium bearing precipitate or solution if not drawn off by the vacuum into the outlet pipe. The filter is conservatively left out of the vacuum filter basin in determining the depth of material in the vacuum filter basin. Case ccs fills only the upper portion (2.1 in.) of the basin with 2 g Pu/cm³ solid, where case ccs1 fills both the upper and lower portions (1 in.) of the basin with the same material which is incredible, based on the amount of plutonium needed to fill the basin. Although not within allowables, case ccs1 shows that even in the case of filling the basin with multiple batches of precipitate from the precipitation tanks, the basin remains subcritical. Case cc103 shows that four boats filled with plutonium oxide in water in a glovebox corner is within allowables. Case cwcc7 shows that over six batches and containers allowed to move about the glovebox when clustered are within allowables. The basis and the details of those contingency scenarios are further illustrated in the following subsections.

5.3.1 Tank Cases

The three precipitation tanks receive feed solution from the blend tanks in HA-227S. If the solution retrieved from PR cans is not properly diluted and blended, and sampling fails, solutions of up to 450 g Pu/L could be received in the precipitation tanks in Glovebox 4.

As shown in Section 5.2.1 for the base case, over the range of 0 to 450 g Pu/L, 250 g Pu/L is the most reactive concentration of plutonium nitrate solution. To cover all possible off-normal events, contingency case ccl is modeled with the three precipitation tanks filled with 250 g Pu/L plutonium nitrate solution. Since each tank is normally loaded with 12 L of 50 g Pu/L, this model covers both an out-of-procedure concentration and out-of-procedure volume of the transferred solution. The tanks are also modeled with six inches of 3 g Pu/cm³ at the bottom of the three precipitation tanks. Each tank has an amount of solids equal to that that could be precipitated from 20 L of 450 g Pu/L solution, 9 kg. This is as much plutonium as can be transferred into the tank because of the maximum concentration of solutions allowed at PFP and the size of the tanks. Each tank has a maximum load of precipitate at an incredible density of 3 g Pu/cm³ for the magnesium hydroxide process and the remaining 16.7 L volume with the most reactive plutonium nitrate solution, 250 g Pu/L for the possible range, 0 to 450 g Pu/L. Each tank is modeled carrying a double worst case loading. The tanks are modeled one inch closer than design and, in one case, 2 ½ in. closer than installed (See Appendix F).

The model of the three precipitation tanks has reflections from one inch thick close fitting water coincident with the six inches of solids and full water reflection from the glovebox sides and bottom. The top gives one inch water reflection. The other tanks and containers have the base case loading.

This worst case model of the precipitation tanks has a k_{eff} of 0.8885 ± 0.0005 . Because this worst case loading is within allowables no limits are required for the precipitation tanks. However, the vacuum filter basin and boat loading have to be restricted. Limits are imposed on the concentration and mass of the feed solution. To limit the boat loading to 2.5 kg of plutonium, the mass per three tank batch is limited to 2.5 kg of plutonium. A concentration limit is also used to limit the mass to Glovebox 3 because the concentration of the feed is to be sampled and confirmed before transfer to Glovebox 3. The 100 g Pu/L concentration limit is an arbitrary value, but it gives ample margin for the process design value of 50 g Pu/L and limits the full precipitation tanks to less than 6 kg. Only a little more than a double batch of 5.5 k_{eff} for the basin and boats.

The phase separator tank, vacuum catch tank, and vacuum trap tank do not normally have liquids with more than 3 g Pu/L. The phase separator tank receives the filtrate from the vacuum filter basin after the precipitation and filtering. Only when the precipitation is incomplete or not filtered will the significant amounts of plutonium be expected in the phase separator tank. Spills in Gloveboxes 3 and 4 can be vacuumed up into the vacuum catch tank as well as filtrate trapped in the vacuum trap tank and gravity drained to the vacuum catch tank. Significant quantities of filtrate are only expected in the vacuum trap tank if there is an over flow in the phase separator tank, or vacuum catch tank, the vacuum would pull the fluids to the vacuum catch tank.

However, the vacuum trap tank is twice as large as the vacuum catch tank and half the volume of the phase separator tanks, so a small overflow can be accommodated. Only a gross break down of operating procedures could get significant accumulations into the vacuum trap tank.

Filling the vacuum trap tank so fluid is sucked into the eductor and out into the glovebox atmosphere and forming a plutonium mist is not considered credible. Fluid expelled from the eductor is expected to collect on surfaces and drip to the floor where it is in a safe configuration limited in depth by the criticality drain.

Although it is unlikely that the critically geometrically favorable 6.186 in. maximum diameter tanks in the vacuum system would receive concentrated plutonium nitrate solution, a model was run of the phase separator tank, the vacuum catch tank, and the vacuum trap tank filled with the most reactive concentration of plutonium nitrate solution, 250 g Pu/L. Only solution is considered because although solids could get to these tanks, the solids can not be in the precipitation tanks, the filter basin, and in these three tanks either. The solids would be more reactive in the precipitation tanks, which are part of this model. The k_{eff} for all six tanks containing feed solution (cc2c) is 0.8893 ± 0.0005 . A small increase in reactivity from the three precipitation tanks case cc1. Filling all tanks with the most reactive feed solution, with solids in the precipitation tanks, vacuum filter basin, and boats, and with the base case reflection is shown to be within the k_{eff} allowable limit of 0.942 for non-metal plutonium systems. Glovebox 3 is double contingent for introduction of and precipitation of plutonium solutions because the worst case precipitate and solution filling all tanks combined has a k_{eff} less than that allowed.

5.3.2 Over Batched Boat

One boat is allowed adjacent to the vacuum filter basin, one on the hot plate, and two at the boat dock. One contingency is to put two batches of plutonium from the vacuum filter basin into a single boat, double batching it.

Case cc3 puts 5.5 kg into a single boat mixing plutonium at metal density with water resulting in a plutonium concentration of 2.44 g Pu/cm^3 and an H/X of 8.25 that fills one boat of 2.25 L. This mixture in one boat adjacent to a 2.75 batched boat has a k_{eff} of 0.8860 ± 0.0005 .

5.3.3 Loss of Spacing Between Boats

Case cc103 arranges four boats in a two by two array in a corner of the glovebox. The boats are arranged long side next to long side. By being in a corner, the array has full water reflection on three sides. The other three sides do not have close fitting water reflection, because hands do not grip a boat to move it. Tongs engage two holes at the end of the boat to move it. The other items in the glovebox are described below and the corner position of the boats is considered to adequately model reflection from operator's bodies, from operator's hands and arms, and from equipment inside the glovebox.

The boats contain 2.75 kg of plutonium oxide mixed with water that fills the boat. This arrangement is the most reactive mixture for a 2.75 kg plutonium batch in a boat volume. The model uses the full volume of the boats. The basin and precipitation tanks contain a 2.75 kg batch of plutonium. The 1/8 in. layer of 3 g Pu/cm³ is retained on the floor. The boats at the boat dock, hot plate, and basin are filled with water. Filling eight boats with a batch of plutonium when only four boats are allowed is considered incredible. The two inch high drip pan is also filled with water to add to the reflectors in the glovebox. The k_{eff} for this model, case cc103, is 0.9312 ± 0.0005 . This contingency case shows that an accidental grouping of four boats with one batch of 2.75 g of plutonium in each is within allowables. This grouping is the contingency case for allowing one boat in transit to move near the boat dock or the basin with an adjacent boat. Because the boat area of the glovebox is so congested, a 25.4 cm (10 in.) spacing of a boat being moved is certainly difficult and may be impossible. This analysis shows that a three boat grouping is double contingent.

Case cc5 takes an extra boat with the base case loading of 2.75 kg of plutonium at metal density mixed with water at a concentration of 1.22 g Pu/cm³ and an H/X of 19 and puts it on top of the two boats in the boat dock. The three boats are arranged with the boats long sides adjacent and with the third boat centered over the two below. All three boats have an inch of water over the exposed top of each boat. Below the bottom two boats is an 1/8 in. layer of 3 g Pu/cm³ of plutonium and below that is full water reflection from below the glovebox floor. This arrangement of boats violates spacing and stacking prohibitions. The k_{eff} of this case is 0.8871 ± 0.0006 . Case cc5 shows having an extra boat stacked is within the k_{eff} allowable limit of 0.942 for non-metal plutonium systems and is doubly contingent.

Since the boat dock has two boats normally and another boat could be in transit close to the boats in the dock, a contingency run is made with all boats allowed in the glovebox in one group. The boats stacking prohibition is violated twice. If four boats are arranged in a wall between the boat dock and the corner of the glovebox against the side of the glovebox as shown in Figure E-16, a k_{eff} of 0.8921 ± 0.0005 results. In this case, cc10, the boats are head-to-head and stacked two high. Each boat has 2.75 kg plutonium in water filling the boat volume. The two boats on the top are covered by an inch of water. The boats at the boat dock, hot plate, and basin, are modeled as water since having eight batches is not credible. The batch in the tanks and in the vacuum basin were kept.

5.3.4 Aggregate of Unspaced Containers

Glovebox 3 has numerous containers that are allowed to move about the glovebox. Case cwcc7 shows that the worst case grouping of these containers with an extra boat is within allowables. This model includes the mass and volume of the containers free to move about the glovebox. The model used is to have batch masses in the vacuum filter basin and around the basin. The cwcc7 model is used to bound the contingent grouping of containers at the basin and at the boat dock. These are the two places in the glovebox where a grouping of containers begins with two adjacent 2.75 kg Pu batches. This case includes four 2.75 kg batches, the 1.5 kg sweeps can, and other containers filled with 250 g Pu/L plutonium nitrate solution. The model includes a boat in transit, one boat allowed next to the basin, and a third boat next to the basin

that is the contingent event to bound the basin area and over four boats to bound the boat dock area.

The worst case arrangement has all the containers grouped around the vacuum filter basin because the basin adds the most volume to the model. None of the containers are stacked. Stacking would violate the stacking limit, introducing a second contingency event. This model explicitly incorporates the mass and volume of: (1) the vacuum filter basin with more than the 2.75 kg batch of plutonium; (2) three boats with a 2.75 kg plutonium batch each; (3) the $\frac{1}{2}$ L sweeps can with 1.5 kg of plutonium; (4) the 1 L leak detection bottle filled with 250 g Pu/L feed solution; (5) three 250 mL pH sample containers filled with 250 g Pu/L feed solution. The twelve sample bottles of up to 50 mL each filled with 3 g Pu/L filtrate are considered bounded by the extra mass and volume in the vacuum filter basin modeled with a larger than the design diameter and the reflection around model and around the glovebox. The boats (2.5 in. high sides), the half liter sweeps can (3.5 in.), and the up to 50 mL sample bottles have the material in these containers normally less than 3 in. high, except the 1 L leak detection bottle which would have 450 g Pu at most. Modeling the containers grouped around the basin as 3.1 in. tall is consistent with the average mass height and based on the fissionable mass being as close to the rest of the fissionable material as possible.

To analyze the aggregate of these five types of containers, two concentric cylinders are arranged around the vacuum filter basin with an inch of water reflector above and around the 3.1 in. tall model. The model has full water reflection below from the water under the floor. The 17.5 in. diameter basin, filled 2.1 in. deep with 1.22 g Pu/L as plutonium oxide in water, includes more volume and mass than that for three boats. Actually the basin is 3.68 boat volumes with a total of 10.1 kg of Pu (3.678 batches). This material is the most moderated material that can be made by the 2.75 kg batch of plutonium allowed in a boat dispersed over the modeled 2.25 L volume of a boat. This material is the most reactive that can be made in a boat by a batch of plutonium. The portion of the basin volume below the perforated plate is modeled conservatively as one inch of water instead of the air that would normally be there.

The 17.5 in. diameter basin with this material bounds the other location in the glovebox that can have four batches with only one contingency, the boat dock. Four boats at the boat dock would cover an area of 22 in. by 10 in. The 17.5 in. diameter basin has a larger area 240.6 sq. inches. The basin is modeled as holding only 3.678 batch masses and volume because the upper basin is only 2.1 in. high. The boats are 2.5 in. high. However, the boats have holes at 1.75 in. above the outside bottom of the boat at the two ends of the boat. Operators do not normally fill the boats above the holes. The 2.1 in. height of the basin is a conservative model of the material in a boat. The model has significant extra plutonium mass because the next concentric cylinder around the basin has the mass and volume of three boats. Also the fissionable material is reflected by one inch of water over the entire top of the model.

The first concentric cylinder around the basin contains the mass and volume of three boats of the same most reactive material as put in the basin. The height of this cylinder is 3.1 in., which is taller than the boats. This adds three boats worth of material to the model. The next concentric cylinder models the remainder of the containers is also 3.1 in. tall. This volume is conservatively filled with 250 g Pu/L plutonium nitrate solution and contains 1.625 kg of

plutonium. The volume is calculated by taking all the mass in the non-boat containers, 1.675 kg Pu, divided by 250 g Pu/L. The 250 g Pu/L is the most reactive concentration of plutonium nitrate solution. The 1.5 kg of plutonium conservatively assumed to be in the half liter sweeps can is being model as the 250 g Pu/L plutonium nitrate solution the increase in volume and increased moderator increases its reactivity. This configuration has a one inch water reflector on the sides and top and full water reflection from the bottom of the glovebox. The tanks are modeled as in the base case with 6 in. of 3 g Pu/L solids (9 kg) and 100 g Pu/L plutonium nitrate solution in the remaining volume of the tank. The k_{eff} for the case cwcc7 is 0.8864 ± 0.0005 . This contingency case shows that an aggregation of four batches and the containers that can move about the glovebox are within the allowable limit of 0.942.

5.3.5 Seismic with Intact Tanks

The analysis of Glovebox 3 depends on the six tanks being spaced as specified in the limits of Section 3 of this CSER. A seismic analysis (Zook 1999) found that a design basis earthquake displaces the tanks only a fraction of an inch. This displacement is less than the 2.54 cm (1 in.) or more tank spacing used in this CSER analysis (see Appendix F). However, the struts and bolting supporting the tanks have not been specified and procured as safety class materials. If the materials are not safety class, their integrity and physical properties can not be assumed to be those specified in the design and used in the seismic displacement analysis. Because the hardware to space the tanks is not safety class, movement of the tank in an earthquake is analyzed as a contingent event in this CSER.

A seismic event that moves the six intact tanks together is considered an unlikely event. The tank contents can be modeled at normal fissionable loading in an unlikely event. Three of the tanks have six inches of 3 g Pu/cm³ as PuO₂ at the bottom of the tanks as precipitate and 10⁻³ g Pu/L filtrate filling the remainder of the tanks. Precipitated plutonium is more reactive than when in solution. The amount and density of plutonium in the three precipitation tanks are conservative. Each of the three tanks contains 9 kg of plutonium, a total of ten batches. The other three tanks in Glovebox 3 normally have no plutonium. In this analysis, they too are modeled as precipitation tanks. The bottom six inches of these tanks also have one inch of water reflection around the outside of the tanks. This is possible because the flanges on the tanks keep the tanks separated by about an inch. For this seismic event, the six tanks are clustered in the center of the glovebox as shown in Figure E-17 in Appendix E. The glovebox is modeled with full water reflection around the sides and bottom. The cluster is not in a corner for maximum reflection and the cluster may not be optimal arranged. However, the cluster is much more tightly packed than could be expected in a seismic event. Full water reflection on the sides and bottom of a smaller glovebox is considered extremely conservative for an earthquake event when operators would not be adjacent to the glovebox and firefighters and fire fighting water would not be surrounding the glovebox with inches of water. Boats are not included in this model because if the tank moves to the end of the glovebox, they are expected to break. And the drip pan, boat dock bar, hot plate shield supports, vacuum filter basin and its piping, struts, and piping are expected to restrict boats to the hot plate area where boats are restricted in normal operations. Since the glovebox is seismically qualified and would remain horizontal, there is no slope to slide the boats toward the tanks. The k_{eff} for the six tank clustered is 0.9207 ± 0.0014 .

This value is less than the 0.942 limit for non-metal plutonium systems and shows that the glovebox is double contingent for an event moving the tanks toward each other.

5.3.6 Seismic and Fire Cases with Broken Tanks

The seismic (cc5) and fire (cc6) contingencies are analyzed with fully loaded boats filled with sprinkler water and 3.25 in. of water on the glovebox floor. For the seismic event, the tanks are modeled as breaking and the solution is added to the water on the glovebox floor above the 1/8 in. holdup layer. Both the density of the water mist in the air and the density of the plutonium oxide in the boats affect the glovebox k_{eff} . Table 5-3-2 lists plutonium densities in water for boats used to calculate the k_{eff} presented in Table 5-3-3. Since the glovebox k_{eff} is shown not to vary with plutonium density in the boats, any of these densities can be used for the parametric study of k_{eff} verses water mist density in the glovebox.

Table 5-3-2. Plutonium/Water Mixture Parameters for Density Range of 0.2 to 5.5 g Pu/cm³ in a Furnace Boat

Pu Density (g/cm ³)	Pu Mass (g)	H ₂ O Mass (g)	Total Mass (g)	Mix Density (g/cm ³)	Wt. Frac. H	Wt. Frac. O	Wt. Frac. Pu	H/X Ratio
0.20	451	2209	2660	1.180	0.0929	0.7383	0.1695	130
0.50	1127	2142	3269	1.451	0.0728	0.5825	0.3447	50
1.00	2253	2030	4284	1.901	0.0527	0.4213	0.5260	24
2.00	2500	1003	3503	2.802	0.0318	0.2544	0.7138	22
5.50	2500	207	2707	5.956	0.0085	0.0680	0.9235	2

Table 5-3-3. Calculational Results for Plutonium/Water Mixtures in a Furnace Boat

Pu Density (g/cm ³)	Without Water on Top of Plutonium		With Water on Top of Plutonium	
	k_{eff}	σ	k_{eff}	σ
0.20	0.8861	0.00059	Boat Full of Plutonium	
0.50	0.8853	0.00064	Boat Full of Plutonium	
1.00	0.8854	0.00058	Boat Full of Plutonium	
2.00	0.8856	0.00061	0.8841	0.00064
5.50	0.8861	0.00058	0.8855	0.00060

The mist atmosphere simulates fire-fighting activities and the general effect of varying density of H₂O filling the glovebox. It also conservatively accounts for large numbers of plastic waste packages used for cleanup in the glovebox. The 1 in. water reflectors around containers and the water around the glovebox are removed from this analysis.

The interspersed moderation analysis at a conservative limiting unit mass (batch) of 2.5 kg plutonium of Glovebox 3 showed (Figure 5.3.1) a monotonically increasing k_{eff} from 0.001 g/cm^3 ($k_{\text{eff}} = 0.8250$, case c111) to full water density ($k_{\text{eff}} = 0.9410$, case c1121). No intermediate peak was identified even though the region around 0.05 g/cm^3 , where a peak has been observed during vault analyses, was examined carefully. Full water flooding is not credible due to the criticality drain. Double contingency is met.

Figure 5.3.1 Interspersed Moderation Contingency

5.3.7 Plutonium Container Against the Glovebox

Plutonium bearing containers are not needed for Gloveboxes 3 and 5 and would not normally be brought around these gloveboxes. However, in the case a plutonium container is brought closer to the glovebox than the 18 in. spacing required by the PFP transportation criticality prevention specification, case cc7 was run. The worst case container for a well moderated and reflected glovebox is the conservative bagless transfer container (BTC) with 4.5 kg at 7.66 g Pu/cm^3 as plutonium nitrate and beryllium oxide filling the remainder of the 2.26 L BTC. The can was modeled against the side of the glovebox inside the full water reflector next to the vacuum filter basin (Figure E-18). The resulting k_{eff} of 0.9105 ± 0.0006 shows that

Glovebox 3 is double contingent for plutonium bearing containers at PFP getting closer than transportation spacing allows.

5.3.8 Double Batched Vacuum Filter Basin

The batch of 2.5 kg of plutonium precipitated allowed in the three precipitation tanks is filtered out of the filtrate by a filter in the vacuum filter basin. The filter is supported by a perforated plate 17 in. in diameter at the bottom of a 2 in. high cylinder around the perforated plate. A space at most an inch deep slopes to the center from the sides below the perforated plate and draws off the filtration with a vacuum. Then the precipitate cake is to be scraped off the filter into a boat. If a second batch of precipitate from the three precipitation tanks were filtered through the vacuum filter basin before the first batch was removed, the basin would be double batched. This event would be a breakdown in the operations procedure and accountability of 2.5 kg of plutonium and is considered an unlikely event.

The basin was modeled as 17.5 in. diameter with 5.5 kg of plutonium at metal density mixed with water filling the upper basin without a filter. A metal water mixture was used in the model because it is more reactive than plutonium hydroxide. The space below the perforated plate was modeled containing air as expected during normal operation of the basin. The conservatism of 450 g Pu/L solution in the conservatively modeled one inch space below the perforated plate in the basin is removed. The double batched vacuum filter basin case cc8 had a k_{eff} of 0.8741 ± 0.0005 . This is within an allowable limit of 0.942 for non-plutonium metal systems and shows the glovebox is double contingent for double batching of the vacuum filter basin.

To ensure that the vacuum filter basin is geometrically favorable to contain precipitation cake, several runs were made filling the basin with dense plutonium oxide. The precipitate cake has been found experimentally to be about 0.2 g Pu/cm^3 . The 2.1 in. deep upper portion above the perforated plate without a filter taking up any room is filled with 2 g Pu/cm^3 density plutonium oxide. This case, ccs, with 14.9 kg of plutonium has a k_{eff} of 0.9352 ± 0.0005 . This value is within the allowable limit of 0.942 so the basin is geometrically favorable for over five batches of precipitate. If the bottom portion below the perforated plate, modeled as one inch deep, is also filled with 2 g Pu/cm^3 density plutonium as oxide, the 22.3 kg of plutonium in the basin has a k_{eff} of 0.9661 ± 0.0006 . Although this case ccs1 result is above the allowable limit, it is adequately subcritical. The 22.3 kg mass accumulation would require almost nine batches of precipitate. Certainly, an incredible amount and it would have to be ten times denser than that resulting from the magnesium hydroxide process. Based on these cases, ccs and ccs1, the vacuum filter basin is considered to be geometrically favorable for use in the magnesium hydroxide process.

5.3.9 Sweep Can

A sweeps can is not explicitly modeled in the base case nor is there a spacing limit on its movement. The sweeps can is limited to a half liter so a full can would only be expected to hold

250 g for conservative density of plutonium precipitate, 0.5 g Pu/cm^3 (See Appendix F), or 570 g for plutonium nitrate, $2.9 \text{ g Pu (NO}_3)_4 \cdot 5\text{H}_2\text{O / cm}^3$. These are the two materials that could be spilled, dry, and then be swept up into a sweeps can. The extra amount of solids modeled in each filtrate tank by being modeled with excessive diameter is far more than is considered credible to be in the sweeps can. This excessive plutonium in the solids of each tank is considered to include the mass that could be in a sweeps can, especially because the precipitation tanks also are filled with plutonium nitrate solution. No control is placed on the movement of the sweeps can because the shape of the solids in the tank is a 6 in. high by 6 in. diameter cylinder. A separate sweeps can with a tank would have a less reactive geometry than an $H=D$ right cylinder formed by the segment of the tank filled with solids. The analysis of the sweeps can among the boats and vacuum filter basin carried out in Section 5.3.4.

5.3.10 High Enriched Uranium

The feed solutions contain both plutonium and uranium. Most uranium enrichments are less than 25 wt. %. Higher enrichment uranium is unlikely but remains a concern. CSER 99-003 (Marusich 1999) reported that for equal mass, Pu-239 is more reactive than U-235 except at fissionable material concentrations of 100 g/L to 1,000 g/L. The report compared the reactivity of high enriched uranium (94 wt. % U-235 in U-238) at different fissionable material concentrations in water with 100 % Pu-239 in water. It showed that uranium (U-235 in U-238) at fissionable material concentrations below 100 g/L and above 1,000 g/L or uranium at enrichments up to 50 wt. % in U-238 is less reactive than equal mass of Pu-239. Uranium solutions of less than 100 g Pu/L are less reactive than the evaluated plutonium at less than 100 g Pu/L. Since feed solutions are limited to uranium with less than 50 wt. % and only uranium solution of less than 100 g Pu/L are allowed to be processed in this glovebox, two limits would have to be exceeded for an enrichment contingency. The double contingency requirement is met by these two limits for the uranium enrichment contingency.

5.3.11 Summary

This CSER shows that the designed magnesium hydroxide process controlled to the limits listed in Section 3.0 is acceptable in Glovebox 3. No single credible event causes the k_{eff} criticality safety limit of 0.95 to be exceeded. A calculational limit of $k_{\text{eff}} = 0.942$ specified in Appendix B is used to account for bias and computational uncertainty. Therefore, this CSER meets the requirements of the Double Contingency Principle for a criticality safety analysis specified in the Hanford Site Nuclear Criticality Safety Manual (HNF 1997b).

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6.0 REFERENCES

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APPENDIX A - INDEPENDENT REVIEW COMMENTS AND CHECKLIST

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FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6537, Rev. 0
 Title: CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Filtrate Storage for Plutonium Stabilization Glovebox 3
 Author: J. S. Lan and E. M. Miller
 Date: 6/30/00
 Scope of Review: MCNP calculations; inputs + outputs.

Yes	No*	NA	
☐	☐	☒	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☐	☐	☒	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
☐	☐	☒	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☐	☐	☒	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☐	☐	☒	Limits/criteria/guidelines checked against references.
☐	☐	☒	Safety margins consistent with good engineering practices.
☐	☐	☒	Conclusions consistent with analytical results and applicable limits.
☐	☐	☒	Results and conclusions address all points required in the problem statement.
☐	☐	☒	Format consistent with applicable guides or other standards.
☐	☐	☒	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

S. R. Gedeon
 Reviewer: (Printed and Signed)

Date 30 June 2000

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6537, Rev. 0
 Title: CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide
 Precipitation Process for Plutonium Stabilization Glovebox 3
 Author: J. S. Lan and E. M. Miller
 Date: 6/30/00

Scope of Review: *This review does not include check of input content files*

Yes	No*	NA	
☒	☐	☐	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
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☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
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☐	☐	☒	Software input correct and consistent with document reviewed.
☐	☐	☒	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☒	☐	☐	Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with applicable guides or other standards.
☐	☐	☐	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

R. F. Richard *R.F. Richard*
 Reviewer: (Printed and Signed)

Date *7/10/00*

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING

Peer Review Comments

R. F. Richard, a qualified Criticality Safety Specialist of the Criticality and Shielding group in FFS, Safety Analysis and Nuclear Engineering, carried out an independent, technical review of HNF-6537, Rev. 0, *CSEER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Precipitation Process for Plutonium Stabilization Glovebox 3*. This review did not include verification of computer input and output files. The following comments were provided.

The evaluation is clearly conservative and demonstrates the double contingency principle. Plutonium nitrate solution (generally up to 330 g Pu/liter, but no greater than 450 g Pu/liter) will be blended to a low concentration in Glovebox 227S. The low concentration nitrate solution (up to 50 g Pu/liter) will be transferred to the precipitation tanks of Glovebox 3. Plutonium Oxide will precipitate out and ultimately be transferred to a furnace boat. The remaining solution (on the order of 1×10^{-3} g Pu/liter) will be transferred to the phase separator tank.

Total plutonium mass in the three precipitation tanks is limited to 2.5 kgs. This limit is driven by the furnace boat 2.5 kg limit (batch process).

The precipitator, phase separator, and vacuum tanks all have a maximum inner diameter of 6.186 inches. ARH-600, Figure III.A.4.100-1, shows that for plutonium nitrate solution in an infinitely long cylinder, the minimum critical diameter is 6.4 inches with full water reflection. The most reactive concentration is 250 g Pu/ liter. For one inch water reflection, the minimum critical diameter is 7.9 inches. The evaluation base case assumed a concentration of 100 g Pu/liter in the precipitation tanks with 6 inches of solids at the bottom of each tank. Also included are 4 furnace boats (2.75 kg plutonium per boat) and an assortment of other containers necessary for the operation. The entire floor of the glovebox is conservatively modeled with a 1/8 inch thick layer of PuO_2 at 3 g Pu/cm^3 . This very conservative base case has a k_{eff} of 0.8825.

Contingencies addressed the criticality parameters of mass, interaction, moderation, volume, concentration, and reflection. Contingencies analyzed were overbatching a boat, solution at optimum concentration, stacking boats, loss of spacing between boats, seismic and fire events. Calculations show that k_{eff} for all contingencies are less than the required 0.942.

Comments generated by this review were incorporated into the document.

This reviewer concurs that no single credible event will cause the 0.95 k_{eff} criticality safety limit to be exceeded. Therefore, this CSER meets the double contingency principle.

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6537, Rev. 0
 Title: CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide
 Precipitation Process for Plutonium Stabilization Glovebox 3
 Author: J. S. Lan and E. M. Miller
 Date: 6/26/00
 Scope of Review:

Yes	No*	NA	
☐	☐	☒	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
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☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
			Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with applicable guides or other standards.
☐		☒	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

W. A. Blyckert *W. A. Blyckert* 6-26-00
 Reviewer: (Printed and Signed)

Date

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

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June 26, 2000

To: Jay S. Lan, Edward M. Miller, and Hans Toffer, Fluor Federal Services, Inc

From: Warner A. Blyckert

Subject: Review of CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Precipitation Process for Plutonium Stabilization Glovebox 3 (HNF-6537 Rev. 0)

Document HNF-6537, Rev. 0, *CSER 00-003: Criticality Safety Evaluation Report for PFP Magnesium Hydroxide Precipitation Process for Plutonium Stabilization Glovebox 3* was given an independent technical review. The approach to analyzing the proposed operations and technique used were checked for suitability, accuracy and completeness.

The material which was reviewed consisted of the draft of the final report. The input and output files of the computer calculations were not reviewed so that no assessment was made of accuracy, convergence, or any other parameter of the results. The correctness and results of the validation effort were not reviewed so that the limits used in the CSER were not checked for accuracy nor applicability other than the narrative account of the approach which is reported in an appendix. The referenced CSERs and CSARs were not reviewed and the statements concerning their results were accepted without verification.

Responses to the reviewer's comments have been incorporated into the final report and adequately address the comments.

The reviewer agrees with the conclusion of the report that the proposed magnesium hydroxide filtrate storage for plutonium stabilization operation may be safely operated with the postulated material under the limiting conditions of operation.

Very truly yours,

Warner A. Blyckert

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APPENDIX B - MCNP4B COMPUTER CODE VALIDATION

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B.1 VALIDATION PROCEDURE

The validation of the computer code methods used in this analysis consisted of testing the code and neutron cross-section calculations against known critical configurations. These benchmark experiments have fissionable isotopes in systems similar to that evaluated by this CSER. The computed and measured k_{eff} 's for the benchmark configurations were compared to establish a bias that includes the uncertainty in the calculational methods. A bias-adjusted k_{eff} for the benchmark systems was defined to include both the deviations for the calculated from the measured k_{eff} 's, and experimental and calculational uncertainties along with the spread in the ability of the computer code to calculate similar systems. In addition, criticality safety criteria require that the bias-adjusted k_{eff} for CSER analysis calculations not exceed the established k_{eff} safety limit at the 95% confidence level.

This method is illustrated in Figure B.1. Critical is defined as a k_{eff} of unity, adjusted by the bias established from the comparison of calculations with benchmarks. The bias combined with the safety margin of 0.05 (a safety limit that k_{eff} must be less than or equal to 0.95) to compare with the calculated value and statistical uncertainty of the computer calculated k_{eff} 's of this CSER analysis. The calculated target k_{eff} is established by adding the bias, 0.05, and 1.645 times the one-sigma uncertainty of the calculated k_{eff} for the particular CSER analysis and subtracting that value from 1.0. For the analyses in this CSER, all the computer statistical uncertainties were less than ± 0.002 , so this value was used to set the target k as described in Section B.2

Figure B.1. Logic of Validation Procedure

B.2 GENERIC VALIDATION FOR PLUTONIUM SYSTEMS

A report by J. S. Lan, *MCNP Version 4B Approval For Use Documentation & Authorized User List* (Lan 1999), presents the results of calculations to determine a generic bias for plutonium configurations, as encountered in the Plutonium Finishing Plant. One hundred and forty three benchmark experiments were calculated. There were different material types that were considered in the plutonium validation calculations:

- Plutonium metal,
- Plutonium oxide,
- Plutonium solutions,
- Plutonium solutions with cadmium (a neutron poison),
- Water and polystyrene moderators, and
- Water, plexiglass, paraffin, polyethylene, and steel and concrete reflectors

The lower tolerance limit b_L was calculated for the benchmark experiments to have a 95% confidence that 95% of the benchmark calculated k_{eff} 's are above that limit. This is expressed by the following formula:

$$b_L = k_{avg} - K_b * \sigma_{avg}$$

where: b_L = lower tolerance limit for 95% confidence that 95% of benchmark calculated k_{eff} 's is above this limit,
 k_{avg} = the average of the k_{eff} 's calculated by MCNP 4B,
 K_b = a multiplier found from statistical tables for non-central t-distribution, and depends on number of degrees of freedom, and
 σ_{avg} = standard deviation of the MCNP k_{eff} 's.

Bias is calculated by the following formula:

$$bias = b_L - k_{crit}$$

where:

k_{crit} = the average of the k_{eff} 's for the critical experiments; for the plutonium experiments $k_{crit} = 1.000$.

The bias for the plutonium metal group was significantly different than for all other groups. For this reason, it was concluded that separate bias values for metal and non-metal groupings would be appropriate. The lower tolerance limit for the metal group (17 benchmark critical experiments) calculated to be 0.9884. The lower tolerance limit for the non-metal group (126 benchmark critical experiments) calculated to be 0.9991. These lower tolerance limits yielded the bias appropriate for each material category:

- Plutonium metal bias is -0.0116,
- Plutonium non-metal bias is -0.0009.

- For conservatism, these calculated biases were recommended to be increased to:

- Plutonium metal recommended bias is -0.0150,
- Plutonium non-metal recommended bias is -0.0050.

The safety criteria for future calculations on undetermined systems requires that the bias-adjusted k_{eff} , k_{eff}^* , does not exceed 0.95 at the 95% confidence level. This is expressed by the following formula:

$$k_{\text{eff}}^* = k_{\text{eff}} - \text{bias} + 1.645 * \sigma_{\text{calc}} \leq k_{\text{limit}}$$

where: k_{eff} = k value given by MCNP 4B calculation for system in question,
 bias = -0.015 for Pu metal, and -0.005 for Pu non-metal systems,
 1.645 = a constant number of standard deviations for .95 of the distribution for a one-sided standard normal distribution
 σ_{calc} = standard deviation given by MCNP 4B calculation for system in question, and
 k_{limit} = 0.95 for plutonium systems, generally.

k_{limit} is generally taken to be 0.95 for plutonium systems.

For a standard deviation (σ_{calc}) of 0.002 or less, the k_{eff}^* value for plutonium metal systems is:

$$k_{\text{eff}} - (-0.015) + 1.645 * 0.002 \leq 0.95, \text{ or}$$

$$k_{\text{eff}} \leq 0.95 + (-0.015) - 1.645 * 0.002 = 0.932.$$

On this basis, it is determined that the true k_{eff} of an analyzed configuration with plutonium will not exceed 0.95 with a 95% confidence level for plutonium metal systems if the calculated value (k_{eff} , and $\sigma \leq 0.002$) is limited to a maximum value of **0.932**.

Figure B.2. Implementation of Validation Procedure

For a standard deviation (σ_{calc}) of 0.002 or less, the k_{eff} value for non-metal systems is:

$$k_{\text{eff}} - (-0.005) + 1.645 * 0.002 \leq 0.95, \text{ or}$$

$$k_{\text{eff}} \leq 0.95 + (-0.005) - 1.645 * 0.002 = 0.942.$$

On this basis, it is determined that the true k_{eff} of an analyzed configuration with plutonium will not exceed 0.95 with a 95% confidence level for plutonium non-metal systems if the calculated value (k_{eff} , and $\sigma \leq 0.002$) is limited to a maximum value of **0.942**.

Figure B.3 Implementation of Validation Procedure

B.3 VALIDATION OF MCNP 4B

The validation of the MCNP4B code on the new computing system, Intergraph™, 400/450 MHz Pentium II, personal computers was documented in Lan, 1999. The essence of the validation was cross-correlation of calculational results obtained with this code version and results of critical experiments, as reported in *MCNP Version 4B Approval for Use Documentation & Authorized User List* (Lan 1999).

APPENDIX C - MCNP INPUT FILES

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Case nca

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mgoh glove box 3 criticality, normal operation case, nca.i
c  glovebox model and outside world,
  1 0
  2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=0 $ outside world
  3 7 -1.00000 19 -20 21 -22 23 -24 imp:n=1 $ outside glovebox
    (-13: 14:-15: 16:-17: 18)
  4 8 -0.00129 13 -14 15 -16 17 -18 #7 #8 #9 imp:n=1 $ 1" of water all around
    #56 #13 #16 #19 #20 #23 #26 #29
    #35 #41 #42 #43 #46 #50 #51 #52 imp:n=1 $ inside glovebox
c  tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
  5 21 -1.06327 -33 -32 31 u=2 imp:n=1 $ tk-001a, pre. tank 40 g/L Pu(NO3)4
  6 8 -0.00129 (33: 32:-31) u=2 imp:n=1 $ air
  7 0 -36 -35 34 trcl=1 fill=2 imp:n=1 $
c  tank relocations (Pu)
  8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
  9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c  tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
  10 25 -1.000001 -33 -32 31 u=13 imp:n=1 $ tk-004 , phase separator tank 36" t
  55 8 -0.001290 (33: 32:-31) u=13 imp:n=1 $ air
  56 0 -36 -35 34 trcl=4 fill=13 imp:n=1 $ 1x10-3 g/L Pu metal, h/x=2.7e+7
c  tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
  11 25 -1.000001 -38 -32 31 u=10 imp:n=1 $ tk-005 , vacuum catch tank 12" t
  12 8 -0.001290 (38: 32:-31) u=10 imp:n=1 $ air
  13 0 -82 -35 34 trcl=5 fill=10 imp:n=1 $ 1x10-3 g/L Pu metal, h/x=2.7e+7
c  tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
  14 25 -1.000001 -37 -32 31 u=11 imp:n=1 $ tk-006 , vacuum trap tank 22" t
  15 8 -0.001290 (37: 32:-31) u=11 imp:n=1 $ air
  16 0 -81 -35 34 trcl=6 fill=11 imp:n=1 $ 1x10-3 g/L Pu metal, h/x=2.7e+7
c  polishing filter model, 6.3" dia. 15.5" T/T
  17 25 -1.000001 -39 -32 31 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
  18 8 -0.001290 (39: 32:-31) u=3 imp:n=1 $ air
  19 0 -83 -35 34 trcl=7 fill=3 imp:n=1 $
c  polishing filter relocation
  20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c  transfer pump model
  21 25 -1.000001 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
  22 8 -0.001290 (75: 74:-73) u=4 imp:n=1 $ air
  23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $
c  drip pan model
  24 25 -1.000001 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
  25 8 -0.00129 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ air
  26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c  sweeps model
  27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
  28 8 -0.00129 (27: 26:-25) u=6 imp:n=1 $ air
  29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c  wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
  30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
  31 8 -0.00129 -41 45 -44 u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
  32 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 2.5 kg PuO2 + 2.5 kg water
  33 14 -2.10 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
  34 8 -0.00129 42 -46 50 u=7 imp:n=1 $ 1" of air surrounding
  35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c  dry filter model
  36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
  37 7 -1.00000 -41 45 -44 u=8 imp:n=1 $ water
  38 7 -1.00000 -41 48 -49 u=8 imp:n=1 $ water
  39 14 -2.10 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
  40 8 -0.00129 42 -46 50 u=8 imp:n=1 $ 1" of air surrounding
  41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c  dry filter model
  42 like 41 but trcl=14 $ dry filter 2
  43 like 41 but trcl=15 $ dry filter 3
c  transition boat model
  44 26 -1.927080 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat
  45 8 -0.00129 (-1: 2:-3: 4: -5: 6) u=9 imp:n=1 $ 1" of water
  46 0 7 -8 9 -10 11 -12 trcl=16 fill=9 imp:n=1 $
c  hot plate boat model
  47 26 -1.927080 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat
  48 15 -0.930000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
  49 11 -7.84 (-7: 8:-9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
  50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c  transition boat relocations
  51 like 46 but trcl=18 $ storage rack boat 1
  52 like 46 but trcl=19 $ storage rack boat 2
  53 like 46 but trcl=20 $ storage rack boat 3
  54 like 46 but trcl=21 $ storage rack boat 4
  55 like 46 but trcl=22 $ extra boat
c  1/8" thick layer of holdup in glove box
  54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup
c  ----- boat ----- 11"x5"x2.5", 2.3 liters -----
  1 py -6.3500
  2 py 6.3500 $ 5"
  3 px -13.9700
  4 px 13.9700 $ 11"
  5 pz -3.1750
  6 pz 3.1750 $ 2.5"
c  ----- boat + 1" h2o -----
  7 py -8.8900
  8 py 8.8900 $ 5" + 1" water
  9 px -16.5100
  10 px 16.5100 $ 11" + 1" water

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11	pz	-5.7150			
12	pz	5.7150	\$ 2.5" + 1" water		
c	-----	glovebox	-----	14"x6.5"x3.5"	-----
13	py	0.0000			
14	py	106.6800	\$ 42" (3.5') wide of glovebox		
15	px	0.9000			
16	px	426.7200	\$ 168" (14.0') long of glovebox		
17	pz	0.0000			
18	pz	198.1200	\$ 78" (6.5') deep of glovebox		
c	-----	glovebox + 12" h2o	-----		-----
19	py	-30.4800			
20	py	137.1600	\$ 42" (3.5') wide of glovebox + 12" of water		
21	px	-30.4800			
22	px	457.2000	\$ 168" (14.0') long of glovebox + 12" of water		
23	pz	-30.4800			
24	pz	228.6000	\$ 78" (6.5') deep of glovebox + 12" of water		
c	-----	glovebox + 12" h2o	-----		-----
19	py	-2.5401	\$ + 1" side (-y dir.)		
20	py	109.2201	\$ 42" (3.5') wide of glovebox + 1" side (+y dir.)		
21	px	-2.5401	\$ + 1" side (-x dir.)		
22	px	429.2601	\$ 168" (14.0') long of glovebox + 1" side (+x dir.)		
23	pz	-2.5401	\$ + 1" bottom (-z dir.)		
24	pz	200.6600	\$ 78" (6.5') deep of glovebox + 1" roof (+z dir.)		
c	-----	sweeps	-----	0.5 liter, 1/4" psi*d*h=500cc, h=d=8.6 cm, r=4.3 cm	-----
25	pz	0.0020			
26	cz	4.3000			
27	pz	8.6000			
c	-----	sweeps + 1" h2o	-----		-----
28	pz	-2.5400			
29	cz	6.8400	\$ 4.30 + 2.54 = 6.84		
30	pz	11.1400	\$ 8.60 + 2.54 = 11.14		
c	-----	precipitate tank	-----	6.3" dia. 26" T 12 liters	TK-001A/B/C
c	-----	phase separator tank	-----	6.3" dia. 26" T 12 liters	TK-004
31	pz	0.0020			
32	cz	8.0019			
33	pz	66.0400	\$ 26" x 2.54 = 66.04		
c	-----	precipitate tank + 1" h2o	-----		-----
c	-----	phase separator tank + 1" h2o	-----		-----
34	pz	-2.5401			
35	cz	10.5410			
36	pz	93.9800			
c	-----	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters	TK-006
37	pz	55.8800			
38	pz	58.3400	\$ + 1" h2o		
c	-----	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters	TK-005
38	pz	30.4800			
39	pz	33.9200	\$ + 1" h2o		
c	-----	polishing filter basin	-----	6.3" dia. 16" T duplex	FL-002A/B
39	pz	40.6400			
40	pz	43.1800	\$ + 1" h2o		
c	-----	vacuum filter basin	-----	17" dia. 2" deep	FL-001
c	-----	drying filter	-----	17" dia. 2" deep	FL-001
41	cz	22.225	\$ 1D pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm	filter	
42	cz	23.495	\$ OD reflector brick (18.5"/2) * 2.54 = 23.495 cm	filter	
43	cz	26.035	\$ (20.5"/2) * 2.54 = 26.035 cm 1" of H2O surrounding the filter		
44	pz	-0.3175	\$ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
45	pz	-2.8575	\$ x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm		
46	pz	-4.1275	\$ 1/2" of reflector brick 2.8575+1/2"*2.54= 4.1275 cm		
47	pz	-6.6675	\$ 1" of H2O 4.1275+ 1"*2.54= 6.6675 cm		
48	pz	0.3175	\$ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
49	pz	2.0010	\$ y for precipitate [Pu(OH)4] above 0.3175+.67"*2.54= 2.0010 cm		
50	pz	3.2710	\$ 1/2" of reflector brick 2.0010+1/2"*2.54= 3.2710 cm		
51	pz	5.8110	\$ 1" of H2O 3.2710+ 1"*2.54= 5.8110 cm		
c	-----	drip pan	-----	1"x1.5"x2" or 12"x18"x2"	-----
61	px	-15.2400			
62	px	15.2400	\$ 12"		
63	py	-22.8600			
64	py	22.8600	\$ 18"		
65	pz	-2.5400			
66	pz	2.5400	\$ 2"		
c	-----	drip pan + 0.001" h2o	-----		-----
67	py	-17.7800			
68	py	17.7800	\$ 12" + 1" water		
69	px	-25.4000			
70	px	25.4000	\$ 18" + 1" water		
71	pz	-5.0800			
72	pz	5.0801	\$ 2" + 1" water		
c	-----	transfer pump	-----	6.7" dia. x 8" wide	p-001&2
73	pz	-10.1600			
74	cz	8.5090			
75	pz	10.1500			
c	-----	transfer pump + 1" h2o	-----		-----
76	pz	-10.1601			
77	cz	8.5091			
78	pz	10.1601			
c	-----	boat + 1" water + 3/4" ss	-----		-----
84	py	-10.7950			
85	py	10.7950	\$ 5" + 1" water + 3/4" ss		
86	px	-18.4150			
87	px	18.4150	\$ 11" + 1" water + 3/4" ss		
88	pz	-7.6200			
89	pz	7.6200	\$ 2.5" + 1" water + 3/4" ss		
c	-----		-----		-----
90	pz	0.3175	\$ 1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup		

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c      25055.50c  0.00155  42000.50c  0.00126  6000.50c  0.0002003 $ ss
c m10  1001.50c -0.0031   8016.50c -0.4407  11023.50c -0.0182  $ Concrete
c      12000.50c -0.0376  13027.50c -0.0607  14000.50c -0.2157  $ concrete
c      15031.50c -0.0009  16032.50c -0.0009  36084.50c -0.0066  $ concrete
c      20000.50c -0.1306  22000.50c -0.0049  26000.55c -0.0788  $ concrete
c m10  lwtr.01t
kcode  6000 1.0 10 600
ksrc   383.53 35.56 60.96
       312.42 35.56 60.96
       233.68 35.56 60.96
       233.56 81.28 60.96
       175.26 72.39 40.64
       127.00 72.39 106.64
       388.62 72.39 96.65
       308.61 72.39 96.65
       330.00 81.28 10.00
       70.00 65.00 10.00
       200.00 25.00 20.00
       144.78 27.00 10.00
       50.00 65.00 150.00
       70.00 65.00 150.00
       90.00 65.00 150.00
       105.00 27.00 10.00
       25.00 20.00 10.00
       55.88 95.00 10.00
       96.52 95.00 10.00
       96.52 95.00 40.00
       96.52 95.00 80.00
       312.42 35.56 10.00
       100.00 50.00 0.15
       200.00 50.00 0.15
       300.00 50.00 0.15
prdnm: j -300 1 3
totnu
print  128
ctme   360
$ tk-001a precipitator tank
$ tk-001b precipitator tank
$ tk-001c precipitator tank
$ tk-004 phase separator tank
$ tk-005 vacuum catch tank
$ tk-006 vacuum trap tank
$ fl-002a polishing filter
$ fl-002b polishing filter
$ p-001 transfer pump x=312.24
$ drip pan
$ sweeps
$ fl-001 wet vacuum filter
$ fl-001 dry vacuum filter 1
$ fl-001 dry vacuum filter 2
$ fl-001 dry vacuum filter 3
$ furnace boat
$ hot plate boat
$ storage rack boat 1
$ storage rack boat 2
$ storage rack boat 3
$ storage rack boat 4
$ extra boat
$ glovebox floor holdup
$ glovebox floor holdup
$ glovebox floor holdup

```

Case hc

```

mgoh glove box 3 criticality, abnormal but anticipated base case, bc.i
c glovebox model and outside world,
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.000000 19 -20 21 -22 23 -24
(-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 90 -18 #7 #8 #9
#56 #13 #16 #19 #20 #23 #26 #29
#35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 29 -1.15800 -33 -32 31 u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.000000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000 -33 -32 31 u=13 imp:n=1 $ tk-004, phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 30 -1.001000 -38 -32 31 u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -82 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 30 -1.001000 -37 -32 31 u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t
15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -92 -32 31 u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728 -41 45 -44 u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
32 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33 7 -1.000000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding

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35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.00000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.00000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.00000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.00000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c transition boat model
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.00000 (-1: 2: -3: 4: -5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8: -9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup

c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500 $ 5"
2 py 6.3500
3 px -13.9700 $ 11"
4 px 13.9700
5 pz -3.1750 $ 2.5"
6 pz 3.1750
c ----- boat + 1" h2o -----
7 py -8.8900 $ 5" + 1" water
8 py 8.8900
9 px -16.5100 $ 11" + 1" water
10 px 16.5100
11 pz -5.7150 $ 2.5" + 1" water
12 pz 5.7150
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510 $ 5" + 1" water
53 py 6.3510
54 px -13.9710 $ 11" + 1" water
55 px 13.9710
56 pz -3.1760 $ 2.5" + 1" of water on top of boat only
57 pz 5.7150
c ----- glovebox ----- 14"x6.5"x3.5' -----
13 py 0.0000 $ 42" ( 3.5') wide of glovebox
14 py 106.6800 $ 168" (14.0') long of glovebox
15 px 0.0000
16 px 426.7203 $ 78" ( 6.5') deep of glovebox
17 pz 0.0000
18 pz 198.1200
c ----- glovebox + 12" h2o -----
19 py -30.4800 $ + 12" side (-y dir.)
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
21 px -30.4800 $ + 12" side (-x dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23 pz -15.2400 $ + 6" bottom (-z dir.)
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- glovebox + 12" h2o -----
c 19 py -2.5401 $ + 1" side (-y dir.)
c 20 py 109.2201 $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
c 21 px -2.5401 $ + 1" side (-x dir.)
c 22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)
c 23 pz -2.5401 $ + 1" bottom (-z dir.)
c 24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- sweeps ----- 0.5 liter, 1/4"pel*d*d+h=500cc, h=d=8.6 cm, r=4.3 cm -----
25 pz 0.0020
26 cz 4.3000
27 pz 8.6000
c ----- sweeps + 1" h2o -----
28 pz -2.5400 $ 4.30 + 2.54 = 6.84
29 cz 6.8400 $ 8.60 + 2.54 = 11.14
30 pz 11.1400
c ----- precipitate tank ----- 6.3" dia. 26" T 12 liters ----- TK-001A/B/C --
c ----- phase separator tank ----- 6.3" dia. 26" T 12 liters ----- TK-004 --
31 pz 0.0020
32 cz 8.0010
33 pz 109.6400 $ 42" x 2.54 = 106.68
c ----- precipitate tank + 1" h2o -----
c ----- phase separator tank + 1" h2o -----
34 pz -2.5401
35 cz 10.5410
36 pz 112.1800
37 pz 15.2500 $ 6" of Pu solid at bottom of 3 precipitation tanks
101 pz 15.2400 $ 6" of water surrounding the tanks
102 cz 8.1000
c ----- vacuum trap tank ----- 6.3" dia. 22" T 11.1 liters ----- TK-006 ---
37 pz 55.8800

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C-8

c	81	pz	58.3400	\$ + 1" h2o				
		vacuum catch tank		6.3" dia. 12" T	5.5 liters	TK-005		
	38	pz	30.4800					
	82	pz	33.0200	\$ + 1" h2o				
c		polishing filter basin		6.3" dia. 16" T duplex		FL-002A/B		
	39	pz	40.6400					
	83	pz	43.1800	\$ + 1" h2o				
c		vacuum filter basin		17" dia. 2" deep		FL-001		
c		drying filter		17" dia. ?" deep		FL-001		
	41	cz	22.225	\$ ID pu(oh)4 precipitate (17.5"/2)	* 2.54 = 22.225 cm		filter	
	42	cz	23.495	\$ OD reflector brick (18.5"/2)	* 2.54 = 23.495 cm		filter	
	43	cz	26.035	\$ (20.5"/2)* 2.54 = 26.035 cm 1"of H2O surrounding the filter				
	44	pz	-0.3175	\$ (.25"/2)* 2.54 = 0.3175 cm 1/4" ss				
	45	pz	-2.8575	\$ x for solution [Mg(NO3)2] below	0.3175+ 1"*2.54= 2.8575 cm			
	46	pz	-4.1275	\$ 1/2" of reflector brick	2.8575+1/2"*2.54= 4.1275 cm			
	47	pz	-6.6675	\$ 1" of H2O	4.1275+ 1"*2.54= 6.6675 cm			
	48	pz	0.3175	\$ (.25"/2)* 2.54 = 0.3175 cm 1/4" ss				
	49	pz	2.1791	\$ y for precipitate [Pu(OH)4] above	0.3175+.73"*2.54= 2.1791 cm			
	50	pz	3.4491	\$ 1/2" of reflector brick	2.1791+1/2"*2.54= 3.4491 cm			
	51	pz	5.9891	\$ 1" of H2O	3.4491+ 1"*2.54= 5.9891 cm			
c		drip pan		1"x1.5"x2" or 12"x18"x2"				
	61	px	-15.2400					
	62	px	15.2400	\$ 12"				
	63	py	-22.8600					
	64	py	22.8600	\$ 18"				
	65	pz	-2.5400					
	66	pz	2.5400	\$ 2"				
c		drip pan + 0.001" h2o						
	67	py	-17.7800					
	68	py	17.7800	\$ 12" + 1" water				
	69	px	-25.4000					
	70	px	25.4000	\$ 18" + 1" water				
	71	pz	-5.0800					
	72	pz	5.0800	\$ 2" + 1" water				
c		transfer pump		6.7" dia.x 8" wide		p-00142		
	73	pz	-10.1600					
	74	cz	8.5090					
	75	pz	10.1600					
c		transfer pump + 1" h2o						
	76	pz	-10.1600					
	77	cz	8.5090					
	78	pz	10.1600					
c		boat + 1" water + 3/4" ss						
	84	py	-10.7950					
	85	py	10.7950	\$ 5" + 1" water + 3/4" ss				
	86	px	-14.4150					
	87	px	14.4150	\$ 11" + 1" water + 3/4" ss				
	88	pz	-7.6200					
	89	pz	7.6200	\$ 2.5" + 1" water + 3/4" ss				
c								
	90	pz	0.3175	\$ 1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup				
	92	pz	20.3200	\$ half of polishing filter height of 16"				
	100	so	600.000	\$ sphere for outside world boundary				
	trl1	3R3.53	35.56	60.96	\$ tk-001a	precipitator	tank	
	trl2	312.42	35.56	60.96	\$ tk-001b	precipitator	tank	
	trl3	233.68	35.56	60.96	\$ tk-001c	precipitator	tank	
	trl4	233.56	81.28	60.96	\$ tk-004	phase separator	tank	
	trl5	175.26	72.39	40.64	\$ tk-005	vacuum catch	tank	
	trl6	127.00	72.39	106.68	\$ tk-006	vacuum trap	tank	
	trl7	388.62	72.39	96.52	\$ fl-002a	polishing	filter	
	trl8	308.61	72.39	96.52	\$ fl-002b	polishing	filter	
	trl9	330.00	81.28	20.00	\$ p-001	transfer	pump	x=312.24

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Case ccl

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mqoh glove box 3 criticality, contingency cases, ccl.i
c glovebox model and outside world,
c 250 g/L Pu(NO3)4 in precipitator tanks with 6" of PuO2 solids at 3 g/cc in bottom
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.00000 19 -20 21 -22 23 -24
(-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 20 -18 #7 #8 #9
#56 #13 #16 #19 #20 #23 #26 #29
#35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 32 -1.39550 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre. tank 250 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.00000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000 -33 -32 31 u=13 imp:n=1 $ tk-004, phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 30 -1.001000 -38 -32 31 u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -82 (-102:-101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 30 -1.001000 -37 -32 31 u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t
15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -92 -32 31 u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -66 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.00000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728 -41 45 -44 u=7 imp:n=1 $ 450 g/L Pu solution (air for normal cond.)
32 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33 7 -1.00000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.00000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.00000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.00000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.00000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.00000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c transition boat model
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.00000 (-1: 2:-3: 4:-5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8:-9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup
c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500 $ 5"
2 py 6.3500 $ 5"
3 px -13.9700 $ 11"
4 px 13.9700 $ 11"
5 pz -3.1750 $ 2.5"
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----

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7	py	-8.8900			
8	py	8.8900	\$	5" + 1" water	
9	px	-16.5100			
10	px	16.5100	\$	11" + 1" water	
11	pz	-5.7150			
12	pz	5.7150	\$	2.5" + 1" water	
c	-----	boat + 1" h2o for all other boats	-----		
52	py	-6.3510			
53	py	6.3510	\$	5" + 1" water	
54	px	-13.9710			
55	px	13.9710	\$	11" + 1" water	
56	pz	-3.1760			
57	pz	5.7150	\$	2.5" + 1" of water on top of boat only	
c	-----	glovebox	-----	14'x6.5'x3.5'	
13	py	0.0000			
14	py	106.6800	\$	42" (3.5') wide of glovebox	
15	px	0.0000			
16	px	426.7200	\$	168" (14.0') long of glovebox	
17	pz	0.0000			
18	pz	198.1200	\$	78" (6.5') deep of glovebox	
c	-----	glovebox + 12" h2o	-----		
19	py	-30.4800	\$	+ 12" side (-y dir.)	
20	py	137.1600	\$	42" (3.5') wide of glovebox + 12" side (+y dir.)	
21	px	-30.4800	\$	+ 12" side (-x dir.)	
22	px	457.2000	\$	168" (14.0') long of glovebox + 12" side (+x dir.)	
23	pz	-15.2400	\$	+ 6" bottom (-z dir.)	
24	pz	200.6600	\$	78" (6.5') deep of glovebox + 1" roof (+z dir.)	
c	-----	glovebox + 12" h2o	-----		
c	19	py	-2.5401	\$	+ 1" side (-y dir.)
c	20	py	109.2201	\$	42" (3.5') wide of glovebox + 1" side (+y dir.)
c	21	px	-2.5401	\$	+ 1" side (-x dir.)
c	22	px	429.2601	\$	168" (14.0') long of glovebox + 1" side (+x dir.)
c	23	pz	-2.5401	\$	+ 1" bottom (-z dir.)
c	24	pz	200.6600	\$	78" (6.5') deep of glovebox + 1" roof (+z dir.)
c	-----	sweeps	-----	0.5 liter, 1/4*pi*d*d*h=500cc, h=d=8.6 cm, r=4.3 cm	
25	pz	0.0020			
26	cz	4.3000			
27	pz	8.6000			
c	-----	sweeps + 1" h2o	-----		
28	pz	-2.5400			
29	cz	6.8400	\$	4.30 + 2.54 = 6.84	
30	pz	11.1400	\$	8.60 + 2.54 = 11.14	
c	-----	precipitate tank	-----	6.3" dia. 26" T 12 liters	TK-001A/B/C
c	-----	phase separator tank	-----	6.3" dia. 26" T 12 liters	TK-004
31	pz	0.0020			
32	cz	8.0010			
33	pz	108.6400	\$	42" x 2.54 = 106.68	
c	-----	precipitate tank + 1" h2o	-----		
c	-----	phase separator tank + 1" h2o	-----		
34	pz	-2.5401			
35	cz	10.5410			
36	pz	112.1800			
91	pz	15.2500	\$	6" of Pu solid at bottom of 3 precipitation tanks	
101	pz	15.2400	\$	6" of water surrounding the tanks	
102	cz	8.1000			
c	-----	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters	TK-006
37	pz	55.8800			
81	pz	58.3400	\$	+ 1" h2o	
c	-----	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters	TK-005
38	pz	30.4800			
92	pz	33.0200	\$	+ 1" h2o	
c	-----	polishing filter basin	-----	6.3" dia. 16" T duplex	FL 002A/B
39	pz	40.6400			
83	pz	43.1800	\$	+ 1" h2o	
c	-----	vacuum filter basin	-----	17" dia. 2" deep	FL-001
c	-----	drying filter	-----	17" dia. 2" deep	FL-001
41	cz	22.225	\$	1D pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm	filter
42	cz	23.495	\$	OD reflector brick (18.5"/2) * 2.54 = 23.495 cm	filter
43	cz	26.035	\$	(20.5"/2)* 2.54 = 26.035 cm 1" of H2O surrounding the filter	
44	pz	-0.3175	\$	(.25"/2)* 2.54 = 0.3175 cm 1/4" ss	
45	pz	-2.8575	\$	x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm	
46	pz	-4.1275	\$	1/2" of reflector brick 2.8575+1/2"*2.54= 4.1275 cm	
47	pz	-6.6675	\$	1" of H2O 4.1275+ 1"*2.54= 6.6675 cm	
48	pz	0.3175	\$	(.25"/2)* 2.54 = 0.3175 cm 1/4" ss	
49	pz	2.1791	\$	y for precipitate [Pu(OH)4] above 0.3175+.73"*2.54= 2.1791 cm	
50	pz	3.4491	\$	1/2" of reflector brick 2.1791+1/2"*2.54= 3.4491 cm	
51	pz	5.9891	\$	1" of H2O 3.4491+ 1"*2.54= 5.9891 cm	
c	-----	drip pan	-----	1'x1.5'x2" or 12"x18"x2"	
61	px	-15.2400			
62	px	15.2400	\$	12"	
63	py	-22.8600			
64	py	22.8600	\$	18"	
65	pz	-2.5400			
66	pz	2.5400	\$	2"	
c	-----	drip pan + 0.001" h2o	-----		
67	py	-17.7800			
68	py	17.7800	\$	12" + 1" water	
69	px	-25.4000			
70	px	25.4000	\$	18" + 1" water	
71	pz	-5.0800			
72	pz	5.0801	\$	2" + 1" water	
c	-----	transfer pump	-----	6.7" dia. x 8" wide	p-00162
73	pz	-10.1600			
74	cz	8.5090			

C-12

[illegible]

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m31 94239.55c -0.533000 8016.50c -0.418000 1001.50c -0.043000 $ 2.75 kg PuO2, h/x=19
mt31 lwtr.01t $ rho=2.263000, boat
c
m32 94239.55c -0.179300 7014.50c -0.042000 8016.50c -0.708000 $ 250 gPu/L in Pu(NO3)4
1001.50c -0.071000 $ rho=1.39550, h/x=95
mt32 lwtr.01t $ for precipitator tank
c
c m1 94239.55c -0.730850 8016.50c -0.250110 1001.50c -0.019040 $ rho=4.104800, gb hold up
c mt1 lwtr.01t
c
c m2 94239.55c -0.047700 8016.50c -0.846500 1001.50c -0.105800 $ rho=1.047500, precipitate tank
c mt2 lwtr.01t
c m3 94239.55c -0.000001 8016.50c -0.888888 1001.50c -0.111111 $ rho=1.000001, phase separator tank
c mt3 lwtr.01t
c m4 94239.55c -0.500000 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
c mt4 lwtr.01t
c m5 94239.55c -0.454300 8016.50c -0.445100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
c mt5 lwtr.01t
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
c mt6 lwtr.01t
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
c mt9 lwtr.01t
c m7 7014.50c 0.790000 8016.50c 0.210000 $ rho=1.001290, air
c m8 1001.50c 0.66667 8016.50c 0.3333 $ rho=1.00, h2o
c mt8 lwtr.01t $ h2o
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
c 25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c m10 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 $ Concrete
c 12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
c 15031.50c -0.0009 16032.50c -0.0009 36084.50c -0.0066 $ concrete
c 20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0789 $ concrete
c mt10 lwtr.01t $ concrete
kcode 6000 1.0 10 600
ksrc 383.53 35.56 60.96 $ tk-001a precipitator tank
312.42 35.56 60.96 $ tk-001b precipitator tank
233.68 35.56 60.96 $ tk-001c precipitator tank
233.56 81.28 60.96 $ tk-004 phase separator tank
175.26 72.39 40.64 $ tk-005 vacuum catch tank
127.00 72.39 106.68 $ tk-006 vacuum trap tank
c 388.62 72.39 96.65 $ fl-002a polishing filter
c 308.61 72.39 96.65 $ fl-002b polishing filter
c 330.00 81.28 10.00 $ p-001 transfer pump x=312.24
c 70.00 65.00 10.00 $
200.00 25.00 20.00 $
144.78 27.00 10.00 $
c 50.00 65.00 150.00 $ fl-001 wet vacuum filter
c 70.00 65.00 150.00 $ fl-001 dry vacuum filter 1
c 90.00 65.00 150.00 $ fl-001 dry vacuum filter 2
c 110.00 27.00 10.00 $ fl-001 dry vacuum filter 3
25.00 20.00 10.00 $
55.88 95.00 10.00 $ furnace boat
96.52 95.00 10.00 $ hot plate boat
96.52 95.00 40.00 $ storage rack boat 1
96.52 95.00 30.00 $ storage rack boat 2
312.42 35.56 10.00 $ storage rack boat 3
100.00 50.00 0.15 $ storage rack boat 4
200.00 50.00 0.15 $ extra boat
300.00 50.00 0.15 $ glovebox floor holdup
$ glovebox floor holdup
$ glovebox floor holdup
prdm 5 -300 1 3
totnu
print 128
ctme 360

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Case cc2a

```

mgoh glove box 3 criticality, contingency cases, cc2a.i
c glovebox model and outside world,
c vacuum tank, phase separator tank, precipitator tank at 65 g/L in Pu(NO3)4 and 36 L
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.00000 19 -20 21 -22 23 -24
(-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 90 -18 #7 #8 #9
#56 #13 #16 #19 #20 #23 #26 #29 imp:n=1 $ inside glovebox
#35 #41 #42 #43 #46 #50 #51 #52 #53
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 29 -1.15800 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre, tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.00000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre, tank 100 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre, tank 100 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 23 -1.102820 -33 -32 31 u=13 imp:n=1 $ tk-004, phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 65 g/L Pu in Pu(NO3)4, h/x=395
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 23 -1.102820 -38 -32 31 u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -82 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 65 g/L Pu in Pu(NO3)4, h/x=395
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 23 -1.102820 -37 -32 31 u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t
15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall

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16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 65 q/L Pu in Pu(NO3)4, h/x=395
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -92 -32 31 u=3 imp:n=1 $ half full of 1 q/L Pu metal, h/x=26,517
18 7 -1.000000 (33: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 q/L Pu metal, h/x=26,517
c drip pan model
24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728 -41 45 -44 u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
32 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33 7 -1.000000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.000000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.000000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.000000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.000000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c transition boat model
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.000000 (-1: 2:-3: 4:-5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8:-9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup

c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500
2 py 6.3500 $ 5"
3 px -13.9700
4 px 13.9700 $ 11"
5 pz -3.1750
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----
7 py -8.8900
8 py 8.8900 $ 5" + 1" water
9 px -16.5100
10 px 16.5100 $ 11" + 1" water
11 pz -5.7150
12 pz 5.7150 $ 2.5" + 1" water
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510 $ 5" + 1" water
54 px -13.9710
55 px 13.9710 $ 11" + 1" water
56 pz -3.1760
57 pz 3.1760 $ 2.5" + 1" of water on top of boat only
c ----- glovebox ----- 14'x6.5'x3.5' -----
13 py 0.0000
14 py 106.6800 $ 42" ( 3.5') wide of glovebox
15 px 0.0000
16 px 426.7200 $ 168" (14.0') long of glovebox
17 pz 0.0000
18 pz 198.1200 $ 78" ( 6.5') deep of glovebox
c ----- glovebox + 12" h2o -----
19 py -30.4800 $
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (-y dir.)
21 px -30.4801 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (-x dir.)
23 pz -15.2400 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 6" bottom (-z dir.)
c ----- glovebox + 12" h2o -----
19 py -2.5401 $ + 1" roof (+z dir.)
c 19 py 109.2201 $ + 1" side (-y dir.)
c 20 px -2.5401 $ + 1" side (+y dir.)
c 21 px 429.2601 $ + 1" side (-x dir.)
c 22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)

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c	23	pz	-2.5401	\$	+ 1" bottom (-z dir.)
c	24	pz	201.6600	\$	78" (6.5') deep of glovebox + 1" roof (+z dir.)
c					
c		-----	sweeps	-----	0.5 liter, 1/4"pei*d*h=500cc, h=d=8.6 cm, r=4.3 cm -----
	25	pz	0.0020		
	26	cz	4.3000		
	27	pz	8.6000		
c		-----	sweeps + 1" h2o	-----	
	28	pz	-2.5400		
	29	cz	6.8400	\$	4.30 + 2.54 = 6.84
	30	pz	11.1400	\$	8.60 + 2.54 = 11.14
c		-----	precipitate tank	-----	6.3" dia. 26" T 12 liters ----- TK-001A/B/C --
c		-----	phase separator tank	-----	6.3" dia. 26" T 12 liters ----- TK-004 --
	31	pz	0.0020		
	32	cz	8.0010		
	33	pz	109.6400	\$	42" x 2.54 = 106.68
c		-----	precipitate tank + 1" h2o	-----	
c		-----	phase separator tank + 1" h2o	-----	
	34	pz	-2.5401		
	35	cz	10.5410		
	36	pz	112.1800		
	91	pz	15.2500	\$	6" of Pu solid at bottom of 3 precipitation tanks
	101	pz	15.2400	\$	6" of water surrounding the tanks
	102	cz	8.1000		
c		-----	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters ----- TK-006 ---
	37	pz	55.8800		
	81	pz	58.3400	\$	+ 1" h2o
c		-----	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters ----- TK-005 ---
	38	pz	30.4800		
	82	pz	33.0200	\$	+ 1" h2o
c		-----	polishing filter basin	-----	6.3" dia. 16" T duplex ----- FL-002A/B ---
	39	pz	40.6400		
	83	pz	43.1800	\$	+ 1" h2o
c		-----	vacuum filter basin	-----	17" dia. 2" deep ----- FL-001 ---
c		-----	drying filter	-----	17" dia. 2" deep ----- FL-001 ---
	41	cz	22.225	\$	ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm filter
	42	cz	23.495	\$	OD reflector brick (18.5"/2) * 2.54 = 23.495 cm filter
	43	cz	26.035	\$	(20.5"/2)* 2.54 = 26.035 cm 1"of H2O surrounding the filter
	44	pz	-0.3175	\$	(.25"/2)* 2.54 = 0.3175 cm 1/4" ss
	45	pz	-2.8575	\$	x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm
	46	pz	-4.1275	\$	1/2" of reflector brick 2.5875+1/2"*2.54= 4.1275 cm
	47	pz	-6.6675	\$	1" of H2O 4.1275+ 1"*2.54= 6.6675 cm
	48	pz	0.3175	\$	(.25"/2)* 2.54 = 0.3175 cm 1/4" ss
	49	pz	2.1791	\$	y for precipitate [Pu(OH)4] above 0.3175+.73"*2.54= 2.1791 cm
	50	pz	3.4491	\$	1/2" of reflector brick 2.1791+1/2"*2.54= 3.4491 cm
	51	pz	5.9891	\$	1" of H2O 3.4491+ 1"*2.54= 5.9891 cm
c		-----	drip pan	-----	1"x1.5"x2" or 12"x18"x2" -----
	61	px	-15.2400		
	62	px	15.2400	\$	12"
	63	py	-22.8600		
	64	py	22.8600	\$	18"
	65	pz	-2.5400		
	66	pz	2.5400	\$	2"
c		-----	drip pan + 0.001" h2o	-----	
	67	py	-17.7300		
	68	py	17.7800	\$	12" + 1" water
	69	px	-25.4000		
	70	px	25.4000	\$	18" + 1" water
	71	pz	-5.0800		
	72	pz	5.0801	\$	2" + 1" water
c		-----	transfer pump	-----	6.7" dia.x 8" wide ----- p-00142-----
	73	pz	-10.1600		
	74	cz	8.5090		
	75	pz	10.1600		
c		-----	transfer pump + 1" h2o	-----	
	76	pz	-10.1601		
	77	cz	8.5091		
	78	pz	10.1601		
c		-----	boat + 1" water + 3/4" ss	-----	
	84	py	-10.7950		
	85	py	10.7950	\$	5" + 1" water + 3/4" ss
	86	px	-18.4150		
	87	px	18.4150	\$	11" + 1" water + 3/4" ss
	88	pz	-7.6200		
	89	pz	7.6200	\$	2.5" + 1" water + 3/4" ss
c		-----		-----	
	90	pz	0.3175	\$	1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup
	92	pz	20.3200	\$	half of polishing filter height of 16"
	100	so	600.000	\$	sphere for outside world boundary
	tr1	383.53	35.56	60.96	\$ tk-001a precipitator tank
	tr2	312.42	35.56	60.96	\$ tk-001b precipitator tank
	tr3	233.68	35.56	60.96	\$ tk-001c precipitator tank
	tr4	233.56	81.28	60.96	\$ tk-004 phase separator tank
	tr5	175.26	72.39	40.64	\$ tk-005 vacuum catch tank
	tr6	127.00	72.39	106.68	\$ tk-006 vacuum trap tank
	tr7	388.62	72.39	96.52	\$ fl-002a polishing filter
	tr8	308.61	72.39	96.52	\$ fl-002b polishing filter
	tr9	330.00	11.28	20.00	\$ p-001 transfer pump x=312.24
	tr10	70.00	65.00	10.00	\$
	tr11	200.00	25.00	10.00	\$
	tr12	144.78	27.00	10.00	\$
	tr13	50.00	65.00	150.00	\$ fl-001 wet vacuum filter
	tr14	70.00	65.00	150.00	\$ fl-001 dry vacuum filter 1
	tr15	90.00	65.00	150.00	\$ fl-001 dry vacuum filter 2
					\$ fl-001 dry vacuum filter 3

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*tr16	110.00	27.00	10.00	90 0 90 180 90 90 90 90 0	\$	furnace	boat
tr17	25.00	20.00	10.00		\$	hot plate	boat
tr18	55.88	95.00	10.00		\$	storage	rack boat 1
tr19	96.52	96.00	10.00		\$	storage	rack boat 2
c	tr20	96.52	95.00	40.00	\$	storage	rack boat 3
c	tr21	96.52	95.00	80.00	\$	storage	rack boat 4
*tr22	312.42	35.56	10.00		\$		extra boat
mode	n						
m7			8016.50c	-0.888889	1001.50c	-0.111111	\$ rho=1.000000, water
lwtr.01t							
m8			8016.50c	-0.235000	7014.50c	-0.765000	\$ rho=0.001290, air
m11	26000.55c	-1.000000					\$ rho=7.84 , ss
m12	1001.50c	-0.076079	8016.50c	-0.608635	94239.50	-0.315286	\$ rho=1.427280, 450 g/l Pu solution
lwtr.01t							\$ filtrate stream
m13	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c	-0.500	\$ rho=1.903890, 40 wt% moisture
lwtr.01t							\$ Pu(OH)4 precipitate
m14	13027.50c	-0.212	20000.50c	-0.007	9019.50c	-0.014	\$ rho=2.010000, reflector brick zone
	8016.50c	-0.497	12000.50c	-0.006	14000.50c	-0.252	\$
	22000.50c	-0.012					\$ reflector brick zone
m15	1001.50c	-0.66666	6000.50c	-0.33334			\$ rho=0.900000, polyethylene
lwtr.01t							
m21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c	-0.850000	\$ 40 gPu/L in Pu(NO3)4
	1001.50c	-0.103000					\$ rho=1.06327, h/x=648
lwtr.01t							\$ for precipitator tank
m22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c	-0.842000	\$ 50 gPu/L in Pu(NO3)4
	1001.50c	-0.101000					\$ rho=1.07909, h/x=525
lwtr.01t							\$ for precipitator tank
m23	94239.55c	-0.059030	7014.50c	-0.014000	8016.50c	-0.829000	\$ 60 gPu/L in Pu(NO3)4
	1001.50c	-0.101000					\$ rho=1.10282, h/x=397
lwtr.01t							\$ for precipitator tank
m24	94239.55c	-0.731000	8016.50c	-0.250000	1001.50c	-0.019000	\$ 3 g Pu/cc in PuO2, h/x=6.23
lwtr.01t							\$ rho=4.101430, floor
m25	94239.55c	-0.000001	8016.50c	-0.888105	1001.50c	-0.111894	\$ 10-3 g/L metal h/x=2.7e+7
lwtr.01t							\$ rho=1.000001, ps tank
m26	94239.55c	-0.465000	8016.50c	-0.482000	1001.50c	-0.053000	\$ 2.5 kg PuO2 , h/x=27
lwtr.01t							\$ rho=1.927080, hp boat
m27	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ 2.5 kg PuO2 50-50 of Pu & water
lwtr.01t							\$ rho=1.903890, vacuum filter basin
m28	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ 1.5 kg, 3 g/cc h/x=7.5
lwtr.01t							\$ rho=3.848640, 0.5 L sweeps
m29	94239.55c	-0.086000	7014.50c	-0.020000	8016.50c	-0.802000	\$ 100 gPu/L in Pu(NO3)4
	1001.50c	-0.092000					\$ rho=1.15800, h/x=256
lwtr.01t							\$ for precipitator tank
m30	94239.55c	-0.001000	8016.50c	-0.888000	1001.50c	-0.111000	\$ 1 g/L Pu, h/x=26,517
lwtr.01t							\$ rho=1.00100, phase separator tank
m31	94239.55c	-0.539000	8016.50c	-0.418000	1001.50c	-0.043000	\$ 2.75 kg PuO2, h/x=19
lwtr.01t							\$ rho=2.263000, boat
m1	94239.55c	-0.730950	8016.50c	-0.250110	1001.50c	-0.019040	\$ rho=4.104800, gb hold up
lwtr.01t							
m2	94239.55c	-0.047700	8016.50c	-0.846500	1001.50c	-0.105800	\$ rho=1.047500, precipitate tank
lwtr.01t							
m3	94239.55c	-0.000001	8016.50c	-0.888888	1001.50c	-0.111111	\$ rho=1.000001, phase separator tank
lwtr.01t							
m4	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ rho=1.903890, vacuum filter basin
lwtr.01t							
m5	94239.55c	-0.454300	8016.50c	-0.485100	1001.50c	-0.060600	\$ rho=1.758500, hot plate boat
lwtr.01t							
m6	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ rho=3.848640, sweep can (a)
lwtr.01t							
m9	94239.55c	-0.570400	8016.50c	-0.381900	1001.50c	-0.047700	\$ rho=2.192000, sweep can (b)
lwtr.01t							
m7	7014.50c	0.790000	8016.50c	0.210000			\$ rho=1.001290, air
m8	1001.50c	0.66667	8016.50c	0.3333			\$ rho=1.00 , h2o
lwtr.01t							\$ h2o
m9	26000.55c	0.05536	24000.50c	0.01641	28000.50c	0.01122	\$ ss
	25055.50c	0.00155	42000.50c	0.00126	6000.50c	0.0002003	\$ ss
m10	1001.50c	-0.0031	8016.50c	-0.4407	11023.50c	-0.0182	\$ Concrete
	12000.50c	-0.0376	13027.50c	-0.0607	14000.50c	-0.2157	\$ concrete
	15031.50c	-0.0009	16032.50c	-0.0009	36084.50c	-0.0066	\$ concrete
	20000.50c	-0.1306	22000.50c	-0.0049	26000.55c	-0.0788	\$ concrete
lwtr.01t							\$ concrete
kscode	6000 1.0	10 600					
ksrc	383.53	35.56	60.96		\$ tk-001a	precipitator	tank
	312.42	35.56	60.96		\$ tk-001b	precipitator	tank
	233.68	35.56	60.96		\$ tk-001c	precipitator	tank

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233.56 81.28 60.96
175.26 72.39 40.64
127.00 72.39 106.68
c 388.62 72.39 96.65
c 308.61 72.39 96.65
c 330.00 81.28 10.00
c 70.00 65.00 10.00
200.00 25.00 20.00
144.78 27.00 10.00
c 50.00 65.00 150.00
c 70.00 65.00 150.00
c 90.00 65.00 150.00
110.00 27.00 10.00
25.00 20.00 10.00
55.88 95.00 10.00
96.52 95.00 10.00
c 96.52 95.00 40.00
c 96.52 95.00 80.00
312.42 35.56 10.00
100.00 50.00 0.15
200.00 50.00 0.15
300.00 50.00 0.15
prdmpr j -300 1 3
totnu
print 128
ctme 360

```

```

$ tk-004 phase separator tank
$ tk-005 vacuum catch tank
$ tk-006 vacuum trap tank
$ fl-002a polishing filter
$ fl-002b polishing filter
$ p-001 transfer pump x=312.24
$ drip pan
$ sweeps
$ fl-001 wet vacuum filter
$ fl-001 dry vacuum filter 1
$ fl-001 dry vacuum filter 2
$ fl-001 dry vacuum filter 3
$ furnace boat
$ hot plate boat
$ storage rack boat 1
$ storage rack boat 2
$ storage rack boat 3
$ storage rack boat 4
$ extra boat
$ glovebox floor holdup
$ glovebox floor holdup
$ glovebox floor holdup

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Case cc2b

```

mqch glove box 3 criticality, contingency cases, cc2b.i
c glovebox model and outside world,
c vacuum tank, phase separator tank, precipitator tank at 40 g/L in Pu(NO3)4 and 60 L
1 0 100 imp:n=0 $ outside world
2 4 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.000000 19 -20 21 -22 23 -24
(-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 90 -18 #7 #8 #9
#56 #13 #16 #19 #20 #23 #26 #29
#35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 29 -1.15800 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.000000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 100 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 100 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 21 -1.063270 -33 -32 31 u=13 imp:n=1 $ tk-004 , phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 40 g/L Pu in Pu(NO3)4, h/x=395
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 21 -1.063270 -38 -32 31 u=10 imp:n=1 $ tk-005 , vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -82 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 40 g/L Pu in Pu(NO3)4, h/x=395
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 21 -1.063270 -37 -32 31 u=11 imp:n=1 $ tk-006 , vacuum trap tank 22" t
15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 40 g/L Pu in Pu(NO3)4, h/x=395
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -32 -32 31 u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -75 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728 -41 45 -44 u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
32 27 -1.90389 -41 48 -43 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33 7 -1.000000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.000000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.000000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.000000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.000000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2

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43      like 41      but trcl=15      $ dry filter 3
c      transition boat model
44 31 -2.263000      1 -2 3 -4 5 -6      u=3 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.000000      (-1: 2: -3: 4: -5: 6)      u=9 imp:n=1 $ 1" of water on top
46 0      52 -53 54 -55 56 -57 trcl=16 fill=9      imp:n=1 $
c      hot plate boat model
47 31 -2.263000      1 -2 3 -4 5 -6      u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000      7 -8 9 -10 11 12 #47      u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84      (-7: 8: -9: 10:-11: 12)      u=12 imp:n=1 $ 3/4" of ss
50 0      84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c      transition boat relocations
51      like 46      but trcl=18      $ storage rack boat 1
52      like 46      but trcl=19      $ storage rack boat 2
c      46      like 46      but trcl=20      $ storage rack boat 3
c      47      like 46      but trcl=21      $ storage rack boat 4
53      like 46      but trcl=22      $ extra boat
c      1/8" thick layer of holdup in glove box
54 24 -4.10143      13 -14 15 -16 17 -90      imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup

c      ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1      py      -6.3500
2      py      6.3500      $ 5"
3      px      -13.9700
4      px      13.9700      $ 11"
5      pz      -3.1750
6      pz      3.1750      $ 2.5"
c      ----- boat + 1" h2o -----
7      py      -8.8900
8      py      8.8900      $ 5" + 1" water
9      px      -16.5100
10     px      16.5100      $ 11" + 1" water
11     pz      -5.7150
12     pz      5.7150      $ 2.5" + 1" water
c      ----- boat + 1" h2o for all other boats -----
52     py      -6.3510
53     py      6.3510      $ 5" + 1" water
54     px      -13.9710
55     px      13.9710      $ 11" + 1" water
56     pz      -3.1760
57     pz      5.7150      $ 2.5" + 1" of water on top of boat only
c      ----- glovebox ----- 14'x6.5'x3.5'-----
13     py      0.0000
14     py      106.6800      $ 42" ( 3.5') wide of glovebox
15     px      0.0000
16     px      426.7200      $ 168" (14.0') long of glovebox
17     pz      0.0000
18     pz      198.1200      $ 78" ( 6.5') deep of glovebox
c      ----- glovebox + 12" h2o -----
19     py      -30.4800      $
20     py      137.1600      $ 42" ( 3.5') wide of glovebox + 12" side (-y dir.)
21     px      -30.4801      $
22     px      457.2000      $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23     pz      -15.2400      $
24     pz      200.6600      $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c      ----- glovebox + 12" h2o -----
19     py      -2.5401      $
20     py      109.2201      $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
21     px      -2.5401      $
22     px      429.2601      $ 168" (14.0') long of glovebox + 1" side (+x dir.)
23     pz      -2.5401      $
24     pz      200.6600      $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c      ----- sweeps ----- 0.5 liter, 1/4"pei*d*d*h=500cc, h=d=8.6 cm, r=4.3 cm -----
25     pz      0.0020
26     cz      4.3000
27     pz      8.6000
c      ----- sweeps + 1" h2o -----
28     pz      -2.5400
29     cz      6.8400      $ 4.30 + 2.54 = 6.84
30     pz      11.1400      $ 8.60 + 2.54 = 11.14
c      ----- precipitate tank ----- 6.3" dia. 26" T 12 liters ----- TK-001A/B/C ---
c      ----- phase separator tank ----- 6.3" dia. 26" T 12 liters ----- TK-004 ---
31     pz      0.0020
32     cz      8.0010
33     pz      109.6400      $ 42" x 2.54 = 106.68"
c      ----- precipitate tank + 1" h2o -----
c      ----- phase separator tank + 1" h2o -----
34     pz      -2.5401
35     cz      10.5410
36     pz      112.1800
91     pz      15.2500      $ 6" of Pu solid at bottom of 3 precipitation tanks
101    pz      15.2400      $ 6" of water surrounding the tanks
102    cz      8.1000
c      ----- vacuum trap tank ----- 6.3" dia. 22" T 11.1 liters ----- TK-006 ---
37     pz      55.8800
81     pz      58.3400      $ + 1" h2o
c      ----- vacuum catch tank ----- 6.3" dia. 12" T 5.5 liters ----- TK-005 ---
38     pz      30.4800
82     pz      33.0200      $ + 1" h2o
c      ----- polishing filter basin ----- 6.3" dia. 16" T duplex ----- FL-002A/B ---
39     pz      40.6400
83     pz      43.1800      $ + 1" h2o
c      ----- vacuum filter basin ----- 17" dia. 2" deep ----- FL-001 ---
c      ----- drying filter ----- 17" dia. 2" deep ----- FL-001 ---
41     cz      22.225      $ ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm filter

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42 cz 23.495 $ OD reflector brick (18.5"/2) * 2.54 = 23.495 cm filter
43 cz 26.035 $ (20.5"/2)* 2.54 = 26.035 cm 1" of H2O surrounding the filter
44 pz -0.3175 $ (.25"/2)* 2.54 = 0.3175 cm 1/4" ss
45 pz -2.8575 $ x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm
46 pz -4.1275 $ 1/2" of reflector brick 2.8575+1/2"*2.54= 4.1275 cm
47 pz -6.6675 $ 1" of H2O 4.1275+ 1"*2.54= 6.6675 cm
48 pz 0.3175 $ (.25"/2)* 2.54 = 0.3175 cm 1/4" ss
49 pz 2.1791 $ y for precipitate [Pu(OH)4] above 0.3175+.73"*2.54= 2.1791 cm
50 pz 3.4491 $ 1/2" of reflector brick 2.1791+1/2"*2.54= 3.4491 cm
51 pz 5.9891 $ 1" of H2O 3.4491+ 1"*2.54= 5.9891 cm

c ----- drip pan ----- 1'x1.5'x2" or 12"x18"x2" -----
61 px -15.2400
62 px 15.2400 $ 12"
63 py -22.8600
64 py 22.8600 $ 18"
65 pz -2.5400
66 pz 2.5400 $ 2"

c ----- drip pan + 0.001" h2o -----
67 py -17.7800
68 py 17.7800 $ 12" + 1" water
69 px -25.4000
70 px 25.4000 $ 18" + 1" water
71 pz -5.0800
72 pz 5.0801 $ 2" + 1" water

c ----- transfer pump ----- 6.7" dia.x 8" wide ----- p-001a2-----
73 pz -10.1600
74 cz 8.5090
75 pz 10.1600

c ----- transfer pump + 1" h2o -----
76 pz -10.1601
77 cz 8.5091
78 pz 10.1601

c ----- boat + 1" water + 3/4" ss -----
84 py -10.7950
85 py 10.7950 $ 5" + 1" water + 3/4" ss
86 px -18.4150
87 px 18.4150 $ 11" + 1" water + 3/4" ss
88 pz -7.6200
89 pz 7.6200 $ 2.5" + 1" water + 3/4" ss

c -----
90 pz 0.3175 $ 1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup
92 pz 20.3200 $ half of polishing filter height of 16"
100 so 600.000 $ sphere for outside world boundary

tr1 383.53 35.56 60.96 $ tk-001a precipitator tank
tr2 312.42 35.56 60.96 $ tk-001b precipitator tank
tr3 233.68 35.56 60.96 $ tk-001c precipitator tank
tr4 233.56 81.28 60.96 $ tk-004 phase separator tank
tr5 175.26 72.39 40.64 $ tk-005 vacuum catch tank
tr6 127.00 72.39 106.68 $ tk-006 vacuum trap tank
tr7 388.62 72.39 96.52 $ fl-002a polishing filter
tr8 308.61 72.39 96.52 $ fl-002b polishing filter
tr9 330.00 81.28 20.00 $ p-001 transfer pump x=312.24
tr10 70.00 65.00 10.00 $
tr11 200.00 25.00 10.00 $
tr12 144.78 27.00 10.00 $ fl-001 wet vacuum filter
*tr13 50.00 65.00 150.00 90 90 0 90 0 90 180 90 90 $ fl-001 dry vacuum filter 1
*tr14 70.00 65.00 150.00 90 90 0 90 0 90 180 90 90 $ fl-001 dry vacuum filter 2
*tr15 90.00 65.00 150.00 90 90 0 90 0 90 180 90 90 $ fl-001 dry vacuum filter 3
*tr16 110.00 27.00 10.00 90 0 90 180 90 90 90 90 0 $ furnace boat
tr17 25.00 20.00 10.00 $ hot plate boat
tr18 55.88 95.00 10.00 $ storage rack boat 1
tr19 96.52 95.00 10.00 $ storage rack boat 2
c tr20 96.52 95.00 40.00 $ storage rack boat 3
c tr21 96.52 95.00 80.00 $ storage rack boat 4
*tr22 312.42 35.56 10.00 $ extra boat

mode n
c
m7 8016.50c -0.888889 1001.50c -0.111111 $ rho=1.000000, water
mt7 lwtr.01t
c
m8 8016.50c -0.235000 7014.50c -0.765000 $ rho=0.001290, air
c
m11 26000.55c -1.000000 $ rho=7.84 , ss
c
m12 1001.50c -0.076073 8016.50c -0.608635 94239.50 -0.315286 $ rho=1.427280, 450 g/l Pu solution
mt12 lwtr.01t $ filtrate stream
c
m13 1001.50c -0.0556 8016.50c -0.4444 94239.55c -0.500 $ rho=1.903890, 40 wt% moisture
mt13 lwtr.01t $ Pu(OH)4 precipitate
c
m14 13027.50c -0.212 20000.50c -0.007 9019.50c -0.014 $ rho=2.010000, reflector brick zone
8016.50c -0.497 12000.50c -0.006 14000.50c -0.252 $
22000.50c -0.012 $ reflector brick zone
c
m15 1001.50c -0.666666 6000.50c -0.333334 $ rho=0.900000, polyethylene
mt15 lwtr.01t
c
m21 94239.55c -0.038000 7014.50c -0.009000 8016.50c -0.850000 $ 40 gPu/L in Pu(NO3)4
1001.50c -0.103000 $ rho=1.06327, h/x=64#
mt21 lwtr.01t $ for precipitator tank
c
m22 94239.55c -0.046000 7014.50c -0.011000 8016.50c -0.842000 $ 50 gPu/L in Pu(NO3)4
1001.50c -0.101000 $ rho=1.07909, h/x=525
mt22 lwtr.01t $ for precipitator tank

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c
m23 94239.55c -0.059000 7014.50c -0.014000 8016.50c -0.829000 $ 60 gPu/L in Pu(NO3)4
      1001.50c -0.101000 $ rho=1.10282, h/x=397
      lwtr.01t $ for precipitator tank
c
m24 94239.55c -0.731000 8016.50c -0.250000 1001.50c -0.019000 $ 3 g Pu/cc in PuO2, h/x=6.23
      lwtr.01t $ rho=4.101430, floor
c
m25 94239.55c -0.000001 8016.50c -0.888105 1001.50c -0.111894 $ 10-3 g/L metal h/x=2.7e+7
      lwtr.01t $ rho=1.000001, ps tank
c
m26 94239.55c -0.465000 8016.50c -0.482000 1001.50c -0.053000 $ 2.5 kg PuO2, h/x=27
      lwtr.01t $ rho=1.927080, hp boat
c
m27 94239.55c -0.500000 8016.50c -0.444400 1001.50c -0.055600 $ 2.5 kg PuO2 50-50 of Pu & water
      lwtr.01t $ rho=1.903890, vacuum filter basin
c
m28 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ 1.5 kg, 3 g/cc h/x=7.5
      lwtr.01t $ rho=3.848640, 0.5 L sweeps
c
m29 94239.55c -0.086000 7014.50c -0.020000 8016.50c -0.802000 $ 100 gPu/L in Pu(NO3)4
      1001.50c -0.092000 $ rho=1.15800, h/x=256
      lwtr.01t $ for precipitator tank
c
m30 94239.55c -0.001000 8016.50c -0.888000 1001.50c -0.111000 $ 1 g/L Pu, h/x=26,517
      lwtr.01t $ rho=1.00100, phase separator tank
c
m31 94239.55c -0.539000 8016.50c -0.418000 1001.50c -0.043000 $ 2.75 kg PuO2, h/x=19
      lwtr.01t $ rho=2.263000, boat
c
c m1 94239.55c -0.730850 8016.50c -0.250110 1001.50c -0.019040 $ rho=4.104800, qb hold up
      lwtr.01t
c
c m2 94239.55c -0.047700 8016.50c -0.846500 1001.50c -0.105800 $ rho=1.047500, precipitate tank
      lwtr.01t
c m3 94239.55c -0.000031 8016.50c -0.888888 1001.50c -0.111111 $ rho=1.000001, phase separator tank
      lwtr.01t
c m4 94239.55c -0.500030 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
      lwtr.01t
c m5 94239.55c -0.454300 8016.50c -0.485100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
      lwtr.01t
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
      lwtr.01t
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
      lwtr.01t
c m7 7014.50c 0.790000 8016.50c 0.210000 $ rho=1.001290, air
c m8 1001.50c 0.666667 8016.50c 0.3333 $ rho=1.00, h2o
      lwtr.01t $ h2o
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
      25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c m10 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0192 $ Concrete
      12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
      15031.50c -0.0009 16032.50c -0.0009 36004.50c -0.0066 $ concrete
      20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788 $ concrete
      lwtr.01t $ concrete
kcode 6000 1.0 10 600
karc 383.53 35.56 60.96 $ tk-001a precipitator tank
      312.42 35.56 60.96 $ tk-001b precipitator tank
      233.68 35.56 60.96 $ tk-001c precipitator tank
      233.56 81.28 60.96 $ tk-004 phase separator tank
      175.26 72.39 40.64 $ tk-005 vacuum catch tank
      127.00 72.39 105.68 $ tk-006 vacuum trap tank
      388.62 72.39 96.65 $ fl-002a polishing filter
      308.61 72.39 96.65 $ fl-002b polishing filter
      330.00 81.28 10.00 $ p-001 transfer pump x=312.24
      70.00 65.00 10.00 $
      200.00 25.00 20.00 $ drip pan
      144.78 27.00 10.00 $ sweeps
      50.00 65.00 150.00 $ fl-001 wet vacuum filter
      70.00 65.00 150.00 $ fl-001 dry vacuum filter 1
      90.00 65.00 150.00 $ fl-001 dry vacuum filter 2
      110.00 27.00 10.00 $ fl-001 dry vacuum filter 3
      25.00 20.00 10.00 $ furnace boat
      55.88 95.00 10.00 $ hot plate boat
      96.52 95.00 10.00 $ storage rack boat 1
      36.52 95.00 40.00 $ storage rack boat 2
      96.52 95.00 80.00 $ storage rack boat 3
      312.42 35.56 10.00 $ storage rack boat 4
      100.00 50.00 0.15 $ glovebox floor holdup
      200.00 50.00 0.15 $ glovebox floor holdup
      300.00 50.00 0.15 $ glovebox floor holdup
prdm p j -300 1 3
totnu
print 128
ctme 360

```

Case cc4

```

mgoh glove box 3 criticality, contingency cases, cc4.i
c glovebox model and outside world
c extra stacked boat (call 53)
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-13: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.00000 19 -20 21 -22 23 -24

```


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```

      (-13: 14:-15: 16:-17: 18)      imp:n=1 $ 12" side 6" bottom 1" top
4   8 -0.00129      13 -14 15 -16 19 -18 #7 #8 #9
      #56 #13 #16 #19 #20 #23 #26 #29 #59
      #35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c   tank model, (Pu)      6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5   29 -1.15800      -33 -32 31      u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57  24 -4.10143      -91 -32 31      u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6   7 -1.00000      (33: 32:-31)      u=2 imp:n=1 $ 1" of surrounding water 6" high
7   0      -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c   tank relocations (Pu)
8   like 7 but trcl=2      $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9   like 7 but trcl=3      $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c   tank model, (Pu)      6.3" dia. 36.0" T/T, 20 liters
10  30 -1.001000      -33 -32 31      u=13 imp:n=1 $ tk-004, phase separator tank 36" t
55  7 -1.000000      (33: 32:-31)      u=13 imp:n=1 $ 1" of water 6" tall
56  0      -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c   tank model, (Pu)      6.3" dia. 12.0" T/T, 5.5 liters
11  30 -1.001000      -38 -32 31      u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12  7 -1.000000      (38: 32:-31)      u=10 imp:n=1 $ 1" of water 6" tall
13  0      -82 (-102:-101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c   tank model, (Pu)      6.3" dia. 22.0" T/T, 11.1 liters
14  30 -1.001000      -37 -32 31      u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t
15  7 -1.000000      (37: 32:-31)      u=11 imp:n=1 $ 1" water 6" tall
16  0      -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c   polishing filter model, 6.3" dia. 15.5" T/T
17  30 -1.001000      -39 -32 92      u=3 imp:n=1 $ fl-002a, polishing filter 16" t
59  30 -1.001000      -32 -32 31      u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18  7 -1.000000      (39: 32:-31)      u=3 imp:n=1 $ 1" of water 6" tall
19  0      -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c   polishing filter relocation
20  like 19 but trcl=8      $ fl-002b, polishing filter 16" t
c   transfer pump model
21  30 -1.001000      -75 -74 73      u=4 imp:n=1 $ pu in transfer pump
22  7 -1.000000      (75: 74:-73)      u=4 imp:n=1 $ 1" of water 6" tall
23  0      -78 -77 76      trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c   drip pan model
24  30 -1.001000      61 -62 63 -64 65 -66      u=5 imp:n=1 $ water in drip pan
25  7 -1.000000      (-61: 62:-63: 64:-65: 66)      u=5 imp:n=1 $ 1" of water around
26  0      67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c   sweeps model
27  29 -3.84864      -27 -26 25      u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28  7 -1.00000      (27: 26:-25)      u=6 imp:n=1 $ air
29  0      -30 -29 28      trcl=11 fill=6 imp:n=1 $
c   wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30  11 -7.84      -41 44 -48      u=7 imp:n=1 $ 25 micron filter (ss)
31  12 -1.42728      -41 45 -44      u=7 imp:n=1 $ 450 g/L Pu solution (air for normal cond.)
32  27 -1.90389      -41 48 -49      u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33  7 -1.00000      (41: 49:-45)      u=7 imp:n=1 $ reflector brick zone
34  7 -1.00000      42 -46 50      u=7 imp:n=1 $ 1" of water surrounding
35  0      -43 47 -51      trcl=12 fill=7 imp:n=1 $
c   dry filter model
36  11 -7.84      -41 44 -48      u=8 imp:n=1 $ 25 micron filter (ss)
37  7 -1.00000      -41 45 -44      u=8 imp:n=1 $ water, bound by 1/8" of hold up
38  7 -1.00000      -41 48 -49      u=8 imp:n=1 $ water, bound by 1/8" of hold up
39  7 -1.00000      (41: 49:-45)      u=8 imp:n=1 $ reflector brick zone
40  7 -1.00000      42 -46 50      u=8 imp:n=1 $ 1" of water surrounding
41  0      -43 47 -51      trcl=13 fill=8 imp:n=1 $
c   dry filter model
42  like 41 but trcl=14      $ dry filter 2
43  like 41 but trcl=15      $ dry filter 3
c   transition boat model
44  31 -2.263000      1 -2 3 -4 5 -6      u=9 imp:n=1 $ furnace boat 2.75 kg
45  7 -1.00000      (-1: 2:-3: 4:-5: 6)      u=9 imp:n=1 $ 1" of water on top
46  0      52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c   hot plate boat model
47  31 -2.263000      1 -2 3 -4 5 -6      u=12 imp:n=1 $ hot plate boat 2.75 kg
48  15 -0.900000      7 -8 9 -10 11 -12 #47      u=12 imp:n=1 $ 1" of polyethylene
49  11 -7.84      (-7: 8:-9: 10:-11: 12)      u=12 imp:n=1 $ 3/4" of ss
50  0      84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c   transition boat relocations
51  like 46 but trcl=18      $ storage rack boat 1
52  like 46 but trcl=19      $ storage rack boat 2
59  like 46 but trcl=20      $ storage rack boat 3
c   47 like 46 but trcl=21      $ storage rack boat 4
53  like 46 but trcl=22      $ extra boat
c   1/8" thick layer of holdup in glove box
54  24 -4.10143      13 -14 15 -16 17 -90      imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup
c   ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1   py -6.3500      $ 5"
2   py 6.3500
3   px -13.9700      $ 11"
4   px 13.9700
5   pz -3.1750
6   pz 3.1750      $ 2.5"
c   ----- boat + 1" h2o -----
7   py -8.8900
8   py 8.8900      $ 5" + 1" water
9   px -16.5100
10  px 16.5100      $ 11" + 1" water
11  pz -5.7150
12  pz 5.7150      $ 2.5" + 1" water
c   ----- boat + 1" h2o for all other boats -----
52  py -6.3510
53  py 6.3510      $ 5" + 1" water

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54	px	-13.9710				
55	px	13.9710	\$	11" + 1" water		
56	pz	-3.1760				
57	pz	5.7150	\$	2.5" + 1" of water on top of boat only		
c	glovebox	-----	14'x6.5'x3.5'	-----		
13	py	0.0000				
14	py	106.6800	\$	42" (3.5') wide of glovebox		
15	px	0.0000				
16	px	426.7200	\$	168" (14.0') long of glovebox		
17	pz	0.0000				
18	pz	198.1200	\$	78" (6.5') deep of glovebox		
c	glovebox + 12" h2o	-----		-----		
19	py	-30.4800	\$		+ 12" side (-y dir.)	
20	py	137.1600	\$	42" (3.5') wide of glovebox	+ 12" side (+y dir.)	
21	px	-30.4801	\$		+ 12" side (-x dir.)	
22	px	457.2000	\$	168" (14.0') long of glovebox	+ 12" side (+x dir.)	
23	pz	-15.2400	\$		+ 6" bottom (-z dir.)	
24	pz	200.6600	\$	78" (6.5') deep of glovebox	+ 1" roof (+z dir.)	
c	glovebox + 12" h2o	-----		-----		
c	19	py	-2.5401	\$	+ 1" side (-y dir.)	
c	20	py	109.2201	\$	42" (3.5') wide of glovebox	+ 1" side (+y dir.)
c	21	px	-2.5401	\$	+ 1" side (-x dir.)	
c	22	px	429.2601	\$	168" (14.0') long of glovebox	+ 1" side (+x dir.)
c	23	pz	-2.5401	\$	+ 1" bottom (-z dir.)	
c	24	pz	200.6600	\$	78" (6.5') deep of glovebox	+ 1" roof (+z dir.)
c	sweeps	-----	0.5 liter, 1/4*pi*d*d*h=500cc, h=d=9.6 cm, r=4.3 cm	-----		
25	pz	0.0020				
26	cz	4.3000				
27	pz	8.6000				
c	sweeps + 1" h2o	-----		-----		
28	pz	-2.5400				
29	cz	6.8400	\$	4.30 + 2.54 = 6.84		
30	pz	11.1400	\$	8.60 + 2.54 = 11.14		
c	precipitate tank	-----	6.3" dia. 26" T 12 liters	-----	TK-001A/B/C --	
c	phase separator tank	-----	6.3" dia. 26" T 12 liters	-----	TK-004 --	
31	pz	0.0020				
32	cz	8.0010				
33	pz	109.6400	\$	42" x 2.54 = 106.68		
c	precipitate tank + 1" h2o	-----		-----		
c	phase separator tank + 1" h2o	-----		-----		
34	pz	-2.5401				
35	cz	10.5410				
36	pz	112.1800				
91	pz	15.2500	\$	6" of Pu solid at bottom of 3 precipitation tanks		
101	pz	15.2400	\$	6" of water surrounding the tanks		
102	cz	8.1000				
c	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters	-----	TK-006 ---	
37	pz	55.8800				
81	pz	58.3400	\$	+ 1" h2o		
c	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters	-----	TK-005 ---	
38	pz	30.4800				
82	pz	33.0200	\$	+ 1" h2o		
c	polishing filter basin	-----	6.3" dia. 16" T duplex	-----	FL-002A/B ---	
39	pz	40.6400				
83	pz	43.1800	\$	+ 1" h2o		
c	vacuum filter basin	-----	17" dia. 2" deep	-----	FL-001 ---	
c	drying filter	-----	17" dia. 2" deep	-----	FL-001 ---	
41	cz	22.225	\$	ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm	filter	
42	cz	23.495	\$	OD reflector brick (18.5"/2) * 2.54 = 23.495 cm	filter	
43	cz	26.035	\$	(20.5"/2) * 2.54 = 26.035 cm 1" of H2O surrounding the filter		
44	pz	-0.3175	\$	(.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
45	pz	-2.8575	\$	x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm		
46	pz	-4.1275	\$	1/2" of reflector brick 2.8575+1/2"*2.54= 4.1275 cm		
47	pz	-6.6675	\$	1" of H2O 4.1275+ 1"*2.54= 6.6675 cm		
48	pz	0.3175	\$	(.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
49	pz	2.1791	\$	y for precipitate [Pu(OH)4] above 0.3175+.73"*2.54= 2.1791 cm		
50	pz	3.4491	\$	1/2" of reflector brick 2.1791+1/2"*2.54= 3.4491 cm		
51	pz	5.9891	\$	1" of H2O 3.4491+ 1"*2.54= 5.9891 cm		
c	drip pan	-----	1'x1.5'x2" or 12"x18"x2"	-----		
61	px	-15.2400				
62	px	15.2400	\$	12"		
63	py	-22.8600				
64	py	22.8600	\$	18"		
65	pz	-2.5400				
66	pz	2.5400	\$	2"		
c	drip pan + 0.001" h2o	-----		-----		
67	py	-17.7800				
68	py	17.7800	\$	12" + 1" water		
69	px	-25.4000				
70	px	25.4000	\$	18" + 1" water		
71	pz	-5.0800				
72	pz	5.0801	\$	2" + 1" water		
c	transfer pump	-----	6.7" dia. x 8" wide	-----	p-001s2-----	
73	pz	-10.1600				
74	cz	8.5090				
75	pz	10.1600				
c	transfer pump + 1" h2o	-----		-----		
76	pz	-10.1601				
77	cz	8.5091				
78	pz	10.1601				
c	boat + 1" water + 3/4" ss	-----		-----		
84	py	-10.7950				
85	py	10.7950	\$	5" + 1" water + 3/4" ss		
96	px	-18.4150				

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c mt3 lwtr.01t
c m4 94239.55c -0.500300 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
c mt4 lwtr.01t
c m5 94239.55c -0.454300 8016.50c -0.485100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
c mt5 lwtr.01t
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
c mt6 lwtr.01t
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
c mt9 lwtr.01t
c m7 7014.50c 0.790000 8016.50c 0.210000 $ rho=1.001290, air
c m8 1001.50c 0.66667 8016.50c 0.3333 $ rho=1.00 , h2o
c mt8 lwtr.01t $
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
c 25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c m10 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 $ Concrete
c 12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
c 15031.50c -0.0009 16032.50c -0.0009 36084.50c -0.0066 $ concrete
c 20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788 $ concrete
c mt10 lwtr.01t $ concrete
kcode 6000 1.0 10 600
karc 383.53 35.56 60.96 $ tk-001a precipitator tank
312.42 35.56 60.96 $ tk-001b precipitator tank
233.68 35.56 60.96 $ tk-001c precipitator tank
233.56 81.28 60.96 $ tk-004 phase separator tank
175.26 72.39 40.64 $ tk-005 vacuum catch tank
127.00 72.39 106.68 $ tk-006 vacuum trap tank
388.62 72.39 96.65 $ fl-002a polishing filter
308.61 72.39 96.65 $ fl-002b polishing filter
330.00 81.28 10.00 $ p-001 transfer pump x=312.24
70.00 65.00 10.00 $
200.00 25.00 20.00 $ drip pan
144.78 27.00 10.00 $ sweeps
50.00 65.00 150.00 $ fl-001 wet vacuum filter
70.00 65.00 150.00 $ fl-001 dry vacuum filter 1
90.00 65.00 150.00 $ fl-001 dry vacuum filter 2
110.00 27.00 10.00 $ fl-001 dry vacuum filter 3
25.00 20.00 10.00 $ furnace boat
55.88 95.00 10.00 $ hot plate boat
96.52 95.00 10.00 $ storage rack boat 1
96.52 95.00 40.00 $ storage rack boat 2
96.52 95.00 80.00 $ storage rack boat 3
312.42 35.56 10.00 $ storage rack boat 4
100.00 50.00 0.15 $ extra boat
200.00 50.00 0.15 $ glovebox floor holdup
300.00 50.00 0.15 $ glovebox floor holdup
prdm p j -300 1 3 $ glovebox floor holdup
rotnu
print 128
ctme 360

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Case cc52

```

mgoh glove box 3 criticality, contingency cases, cc52.i
c glovebox model and outside world,
c seismic - base + sprinklers + break tanks, 3 precipitator tanks are empty except 6" of solid
c add a bottom cell (cell 59) into negative z direction suggested by Carol [to avoid half merged (sink) components]
c back to the plunging geometry, cc51: water
c cc52: 250 g Pu/L solution on floor
c cc53: take 1" of 450 g/L Pu solution at filter basin away
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.00000 19 -20 21 -22 23 -24 (-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 93 -18 #7 #8 #9 #56 #13 #16 #19 #20 #23 #41 #42 #43 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 8 -0.00129 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre, tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.00000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000 -33 -32 31 u=13 imp:n=1 $ tk-004 , phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 30 -1.001000 -38 -32 31 u=10 imp:n=1 $ tk-005 , vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -82 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 30 -1.001000 -37 -32 31 u=11 imp:n=1 $ tk-006 , vacuum trap tank 22" t
15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -92 -32 31 u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model

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21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter basin model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728 -41 45 -44 u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
32 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
33 7 -1.000000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.000000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.000000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.000000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.000000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c change basin boat to hot plate boat model for sinking reason
44 31 -2.263000 1 -2 3 -4 5 6 u=9 imp:n=1 $ basin boat 2.75 kg
45 7 -1.000000 (-1: 2:-3: 4:-5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=17 fill=9 imp:n=1 $
c hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8:-9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
53 like 46 but trcl=20 $ storage rack boat 3
54 like 46 but trcl=21 $ storage rack boat 4
55 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 32 -1.39550 13 -14 15 -16 17 -93
#26 #29 #35 #46 #51 #52 #53 imp:n=1 $ 250 g Pu/L as Pu(NO3)4 solution on floor
c 59 34 -1.02970 13 -14 15 -16 90 -93 imp:n=1 $ bottom cell for tank leak
c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500
2 py 6.3500 $ 5"
3 px -13.9700
4 px 13.9700 $ 11"
5 pz -3.1750
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----
7 py -8.8900
8 py 8.8900 $ 5" + 1" water
9 px -16.5100
10 px 16.5100 $ 11" + 1" water
11 pz -3.7151
12 pz 3.7151 $ 2.5" + 1" water
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510 $ 5" + 1" water
54 px -13.9710
55 px 13.9710 $ 11" + 1" water
56 pz -3.1751
57 pz 3.1751 $ 2.5" + 1" of water on top of boat only
c ----- glovebox ----- 14'x6.5'x3.5' -----
13 py 0.0000
14 py 106.6800 $ 42" ( 3.5') wide of glovebox
15 px 0.0000
16 px 426.7200 $ 168" (14.0') long of glovebox
17 pz 0.0000
18 pz 198.1200 $ 78" ( 6.5') deep of glovebox
c ----- glovebox + 12" h2o -----
19 py -30.4800 $ + 12" side (-y dir.)
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
21 px -30.4801 $ + 12" side (-x dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23 pz -22.8600 $ + 6" bottom (-z dir.) + 3"
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- glovebox + 12" h2o -----
19 py -2.5401 $ + 1" side (-y dir.)
20 py 109.2201 $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
21 px -2.5401 $ + 1" side (-x dir.)
22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)
23 pz -2.5401 $ + 1" bottom (-z dir.)
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- sweeps ----- 0.5 liter, 1/4*pei*d*d*h=500cc, h=d=8.6 cm, r=4.30 cm -----
c ----- sweeps ----- 0.5 liter, 1/4*pei*d*d*h=500cc, h = 6 cm, r=5.15 cm -----
25 pz 0.002
26 cz 5.15023

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27	pz	6.0000							
c	-----	sweeps + 1" h2o							
28	pz	0.001							
29	cz	5.15033	\$ 4.30 + 2.54 = 6.84						
30	pz	6.0001	\$ 8.60 + 2.54 = 11.14						
c	-----	precipitate tank	-----	6.3" dia. 26" T 12 liters	-----	TK-001A/B/C	---		
c	-----	phase separator tank	-----	6.3" dia. 26" T 12 liters	-----	TK-004	---		
31	pz	0.0020							
32	cz	8.0010							
33	pz	109.6400	\$ 42" x 2.54 = 106.68						
c	-----	precipitate tank	+ 1" h2o						
c	-----	phase separator tank	+ 1" h2o						
34	pz	-2.5401							
35	cz	10.5410							
36	pz	112.1800							
101	pz	15.2400	\$ 6" of water surrounding the tanks						
102	cz	8.1000							
c	-----	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters	-----	TK-006	---		
37	pz	55.8800							
81	pz	58.3400	\$ + 1" h2o						
c	-----	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters	-----	TK-005	---		
38	pz	30.4800							
82	pz	33.0200	\$ + 1" h2o						
c	-----	polishing filter basin	--	6.3" dia. 16" T duplex	-----	FL-002A/B	---		
39	pz	40.6400							
83	pz	43.1800	\$ + 1" h2o						
c	-----	vacuum filter basin	--	17" dia. 2" deep	-----	FL-001	---		
c	-----	drying filter	--	17" dia. ?" deep	-----	FL-001	---		
41	cz	22.225	\$ 1D pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm						
42	cz	23.495	\$ OD reflector brick (18.5"/2) * 2.54 = 23.495 cm						
43	cz	26.035	\$ (20.5"/2) * 2.54 = 26.035 cm 1" of H2O surrounding the filter						
44	pz	-0.3175	\$ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss						
45	pz	-2.8575	\$ x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm						
46	pz	-2.8576	\$ 1/2" of reflector brick 2.5875+1/2"*2.54= 4.1275 cm						
47	pz	-2.8577	\$ 1" of H2O 4.1275+ 1"*2.54= 6.6675 cm						
48	pz	0.3175	\$ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss						
49	pz	2.1791	\$ y for precipitate [Pu(OH)4] above 0.3175+.73"*2.54= 2.1791 cm						
50	pz	2.1792	\$ 1/2" of reflector brick 2.1791+1/2"*2.54= 3.4491 cm						
51	pz	2.1793	\$ 1" of H2O 3.4491+ 1"*2.54= 5.9891 cm						
c	-----	drip pan	-----	1'x1.5'x2" or 12"x18"x2"					
61	px	-15.2400							
62	px	15.2400	\$ 12"						
63	py	-22.8600							
64	py	22.8600	\$ 18"						
65	pz	-2.5400							
66	pz	2.5400	\$ 2"						
c	-----	drip pan + 0.001" h2o							
67	py	-15.2410							
68	py	15.2410	\$ 12" + 1" water						
69	px	-22.4610							

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c	tr21	96.52	95.00	80.00		\$	storage	rack boat 4
*tr22	312.42	35.56	4.00			\$		extra boat
mode	n							
c								
m7			8016.50c	-0.888889	1001.50c	-0.111111	\$ rho=1.000000,	water
mt7	lwtr.01t							
c								
m8			8016.50c	-0.235000	7014.50c	-0.765000	\$ rho=0.001290,	air
c								
m11	26000.55c	-1.000000					\$ rho=7.84	, ss
c								
m12	1001.50c	-0.076079	8016.50c	-0.608635	94239.50	-0.315286	\$ rho=1.427280,	450 g/l Pu solution
mt12	lwtr.01t						\$	filtrate stream
c								
m13	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c	-0.500	\$ rho=1.903890,	40 wt% moisture
mt13	lwtr.01t						\$	Pu(OH)4 precipitate
c								
m14	13027.50c	-0.212	20000.50c	-0.007	9019.50c	-0.014	\$ rho=2.010000,	reflector brick zone
	8016.50c	-0.497	12000.50c	-0.006	14000.50c	-0.252	\$	
	22000.50c	-0.012					\$	reflector brick zone
c								
m15	1001.50c	-0.66666	6000.50c	-0.33334			\$ rho=0.900000,	polyethylene
mt15	lwtr.01t							
c								
m21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c	-0.850000	\$ 40 gPu/L in Pu(NO3)4	
	1001.50c	-0.103000					\$ rho=1.06327,	h/x=648
mt21	lwtr.01t						\$	for precipitator tank
c								
m22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c	-0.842000	\$ 50 gPu/L in Pu(NO3)4	
	1001.50c	-0.101000					\$ rho=1.07909,	h/x=525
mt22	lwtr.01t						\$	for precipitator tank
c								
m23	94239.55c	-0.059000	7014.50c	-0.014000	8016.50c	-0.829000	\$ 60 gPu/L in Pu(NO3)4	
	1001.50c	-0.101000					\$ rho=1.10282,	h/x=397
mt23	lwtr.01t						\$	for precipitator tank
c								
m24	94239.55c	-0.731000	8016.50c	-0.250000	1001.50c	-0.019000	\$ 3 g Pu/cc in PuO2,	h/x=6.23
mt24	lwtr.01t						\$ rho=4.101430,	floor
c								
m25	94239.55c	-0.000001	8016.50c	-0.888105	1001.50c	-0.111894	\$ 10-3 g/L metal h/x=2.7e+7	
mt25	lwtr.01t						\$ rho=1.000001,	ps tank
c								
m26	94239.55c	-0.465000	8016.50c	-0.482000	1001.50c	-0.053000	\$ 2.5 kg PuO2,	h/x=27
mt26	lwtr.01t						\$ rho=1.927080,	hp boat
c								
m27	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ 2.5 kg PuO2 50-50 of Pu & water	
mt27	lwtr.01t						\$ rho=1.903890,	vacuum filter basin
c								
m28	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ 1.5 kg, 3 g/cc h/x=7.5	
mt28	lwtr.01t						\$ rho=3.848640,	0.5 L sweeps
c								
m29	94239.55c	-0.086000	7014.50c	-0.020000	8016.50c	-0.802000	\$ 100 gPu/L in Pu(NO3)4	
	1001.50c	-0.092000					\$ rho=1.15800,	h/x=256
mt29	lwtr.01t						\$	for precipitator tank
c								
m30	94239.55c	-0.001000	8016.50c	-0.888000	1001.50c	-0.111000	\$ 1 g/L Pu, h/x=26,517	
mt30	lwtr.01t						\$ rho=1.00100,	phase separator tank
c								
m31	94239.55c	-0.539000	8016.50c	-0.418000	1001.50c	-0.043000	\$ 2.75 kg PuO2,	h/x=19
mt31	lwtr.01t						\$ rho=2.263000,	boat
c								
m32	94239.55c	-0.179000	7014.50c	-0.042000	8016.50c	-0.708000	\$ 250 gPu/L in Pu(NO3)4	
	1001.50c	-0.071000					\$ rho=1.39550,	h/x=95
mt32	lwtr.01t						\$	for precipitator tank
c								
m34	94239.55c	-0.018000	7014.50c	-0.004000	8016.50c	-0.871000	\$ 18.8 gPu/L in Pu(NO3)4	
	1001.50c	-0.107000					\$ rho=1.02970,	h/x=1421
mt34	lwtr.01t						\$	for precipitator tank
c								
m1	94239.55c	-0.730850	8016.50c	-0.250110	1001.50c	-0.019040	\$ rho=4.104800,	gh hold up
mt1	lwtr.01t							
c								
m2	94239.55c	-0.047700	8016.50c	-0.846500	1001.50c	-0.105800	\$ rho=1.047500,	precipitate tank
mt2	lwtr.01t							
c								
m3	94239.55c	-0.000001	8016.50c	-0.888888	1001.50c	-0.111111	\$ rho=1.000001,	phase separator tank
mt3	lwtr.01t							
c								
m4	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ rho=1.903890,	vacuum filter basin
mt4	lwtr.01t							
c								
m5	94239.55c	-0.454300	8016.50c	-0.485100	1001.50c	-0.060600	\$ rho=1.758500,	hot plate boat
mt5	lwtr.01t							
c								
m6	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ rho=3.848640,	sweep can (a)
mt6	lwtr.01t							
c								
m9	94239.55c	-0.570400	8016.50c	-0.381900	1001.50c	-0.047700	\$ rho=2.182000,	sweep can (b)
mt9	lwtr.01t							
c								
m7	7014.50c	0.790000	8016.50c	0.210000			\$ rho=1.001290,	air
mt7	lwtr.01t						\$ rho=1.00	, h2o
c							\$	h2o
m9	26000.55c	0.05536	24000.50c	0.01641	28000.50c	0.01122	\$ ss	
c	25055.50c	0.00155	42000.50c	0.00126	6000.50c	0.0002003	\$ ss	
c	1001.50c	-0.0031	8016.50c	-0.4407	11023.50c	-0.0182	\$ Concrete	
c	12000.50c	-0.0376	13027.50c	-0.0607	14000.50c	-0.2157	\$ concrete	
c	15031.50c	-0.0009	16032.50c	-0.0009	36084.50c	-0.0066	\$ concrete	
c	20000.50c	-0.1306	22000.50c	-0.0049	26000.55c	-0.0788	\$ concrete	
mt10	lwtr.01t						\$ concrete	
kecode	6000 1.0 10 600							

ksrc	383.53	35.56	60.96	\$	tk-001a	precipitator	tank
	312.42	35.56	60.96	\$	tk-001b	precipitator	tank
	233.68	35.56	60.96	\$	tk-001c	precipitator	tank
	233.56	81.28	60.96	\$	tk-004	phase separator	tank
	175.26	72.39	40.64	\$	tk-005	vacuum catch	tank
	127.00	72.39	106.68	\$	tk-006	vacuum trap	tank
c	388.62	72.39	96.65	\$	fl-002a	polishing	filter
c	308.61	72.39	96.65	\$	fl-002b	polishing	filter
c	330.00	81.28	10.00	\$	p-001	transfer	pump x=312.24
c	70.00	65.00	10.00	\$			drip pan
	200.00	25.00	1.00	\$			sweeps
	144.78	27.00	3.00	\$	fl-001	wet vacuum	filter
c	50.00	65.00	150.00	\$	fl-001	dry vacuum	filter 1
c	70.00	65.00	150.00	\$	fl-001	dry vacuum	filter 2
c	30.00	65.00	150.00	\$	fl-001	dry vacuum	filter 3
c	110.00	27.00	10.00	\$		filter basin	boat
	25.00	20.00	4.00	\$		hot plate	boat
	55.88	95.00	4.00	\$		storage	rack boat 1
c	96.52	95.00	4.00	\$		storage	rack boat 2
c	96.52	95.00	43.00	\$		storage	rack boat 3
c	96.52	95.00	83.00	\$		storage	rack boat 4
	312.42	35.56	4.00	\$			extra boat
	100.00	50.00	0.15	\$		glovebox	floor holdup
	200.00	50.00	0.15	\$		glovebox	floor holdup
	300.00	50.00	0.15	\$		glovebox	floor holdup
prdm	i	-300	1	3			
totnu							
print	12#						
ctme	360						

Case cc7

mgoh glove box 3 criticality, contingency cases, cc7.i

c glovebox model and outside world,

c fissile container brought too close to the side of qb3, 4.5 kg, 7.66 g/cc, h/x=1.5, PuN, BeO

1 0 100 imp:n=0 \$ outside world

2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 \$ outside glovebox

3 7 -1.00000 19 -20 21 -22 23 -24

4 8 -0.00129 (-13: 14:-15: 16:-17: 18) #64 imp:n=1 \$ 12" side 6" bottom 1" top

13 -14 15 -16 90 -18 #7 #8 #9

#56 #13 #16 #19 #20 #23 #26 #29

#35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 \$ inside glovebox

c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case

5 29 -1.15800 -33 -32 31 u=2 imp:n=1 \$ tk-001a, pre. tank 100 g/L Pu(NO3)4

57 24 -4.10143 -91 -32 31 u=2 imp:n=1 \$ 6" of Pu solid at bottom of 3 precipitation tanks

6 7 -1.00000 (33: 32:-31) u=2 imp:n=1 \$ 1" of surrounding water 6" high

7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 \$

c tank relocations (Pu)

8 like 7 but trcl=2 \$ tk-001b, pre. tank 40 g/L Pu(NO3)4

3 like 7 but trcl=3 \$ tk-001c, pre. tank 40 g/L Pu(NO3)4

c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters

10 30 -1.001000 -33 -32 31 u=13 imp:n=1 \$ tk-004, phase separator tank 36" t

55 7 1.000000 (33: 32:-31) u=13 imp:n=1 \$ 1" of water 6" tall

56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 \$ 1 g/L Pu metal, h/x=26,517

c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters

11 30 -1.001000 -38 -32 31 u=10 imp:n=1 \$ tk-005, vacuum catch tank 12" t

12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 \$ 1" of water 6" tall

13 0 -82 (-102:-101) -35 34 trcl=5 fill=10 imp:n=1 \$ 1 g/L Pu metal, h/x=26,517

c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters

14 30 -1.001000 -37 -32 31 u=11 imp:n=1 \$ tk-006, vacuum trap tank 22" t

15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 \$ 1" water 6" tall

16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 \$ 1 g/L Pu metal, h/x=26,517

c polishing filter model, 6.3" dia. 15.5" T/T

17 30 -1.001000 -39 -32 92 u=3 imp:n=1 \$ fl-002a, polishing filter 16" t

58 30 -1.001000 -92 -32 31 u=3 imp:n=1 \$ half full of 1 g/L Pu metal, h/x=26,517

18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 \$ 1" of water 6" tall

19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 \$

c polishing filter relocation

20 like 19 but trcl=8 \$ fl-002b, polishing filter 16" t

c transfer pump model

21 30 -1.001000 -75 -74 73 u=4 imp:n=1 \$ pu in transfer pump

22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 \$ 1" of water 6" tall

23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 \$ 1 g/L Pu metal, h/x=26,517

c drip pan model

24 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 \$ water in drip pan

25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 \$ 1" of water around

26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 \$

c sweeps model

27 28 -3.84864 -27 -26 25 u=6 imp:n=1 \$ 1.5 kg, 3 g/cc, h/x=7.5

28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 \$ air

29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 \$

c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"

30 11 -7.84 -41 44 -48 u=7 imp:n=1 \$ 25 micron filter (ss)

31 12 -1.42728 -41 45 -44 u=7 imp:n=1 \$ 450 g/L Pu solution (air for normal cond.)

32 27 -1.90389 -41 48 -49 u=7 imp:n=1 \$ 2.75 kg PuO2 + 2.75 kg water

33 7 -1.000000 (41: 49:-45) u=7 imp:n=1 \$ reflector brick zone

34 7 -1.000000 42 -46 50 u=7 imp:n=1 \$ 1" of water surrounding

35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 \$

c dry filter model

36 11 -7.84 -41 44 -48 u=8 imp:n=1 \$ 25 micron filter (ss)

37 7 -1.000000 -41 45 -44 u=8 imp:n=1 \$ water, bound by 1/8" of hold up

38 7 -1.000000 -41 48 -49 u=8 imp:n=1 \$ water, bound by 1/8" of hold up

39 7 -1.000000 (41: 49:-45) u=8 imp:n=1 \$ reflector brick zone

40 7 -1.000000 42 -46 50 u=8 imp:n=1 \$ 1" of water surrounding

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c 41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
dry filter model
c 42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c 44 transition boat model
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.000000 (-1: 2: -3: 4: -5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c 47 hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8: -9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c 51 transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup
c 4.5 kg can model, 7.66 g/cc, h/x=1.5
61 35 -8.540300 -111 112 -119 u=1 imp:n=1 $ PuN in can 1
62 7 -1.000000 -111 119 -113 u=1 imp:n=1 $ water in can
63 36 -3.010000 (111:-112: 113) u=1 imp:n=1 $ BeO
64 0 -116 (-117:-118) -114 115 trcl=23 fill=1 imp:n=1 $

c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500
2 py 6.3500 $ 5"
3 px -13.9700
4 px 13.9700 $ 11"
5 pz -3.1750
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----
7 py -8.8900
8 py 8.8900 $ 5" + 1" water
9 px -16.5100
10 px 16.5100 $ 11" + 1" water
11 pz -5.7150
12 pz 5.7150 $ 2.5" + 1" water
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510 $ 5" + 1" water
54 px -13.9710
55 px 13.9710 $ 11" + 1" water
56 pz -3.1760
57 pz 5.7150 $ 2.5" + 1" of water on top of boat only
c ----- glovebox ----- 14"x6.5"x3.5" -----
13 py 0.0000
14 py 106.6800 $ 42" ( 3.5') wide of glovebox
15 px 0.0000
16 px 426.7200 $ 168" (14.0') long of glovebox
17 pz 0.0000
18 pz 198.1200 $ 78" ( 6.5') deep of glovebox
c ----- glovebox + 12" h2o -----
19 py -30.4800 $ + 12" side (-y dir.)
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
21 px -30.4801 $ + 12" side (-x dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23 pz -15.2400 $ + 6" bottom (-z dir.)
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- glovebox + 12" h2o -----
c 19 py -2.5401 $ + 1" side (-y dir.)
c 20 py 109.2201 $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
c 21 px -2.5401 $ + 1" side (-x dir.)
c 22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)
c 23 pz -2.5401 $ + 1" bottom (-z dir.)
c 24 pz 200.6601 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- sweeps ----- 0.5 liter, 1/4*pi*d*d*h=500cc, h=d=8.6 cm, r=4.3 cm -----
25 pz 0.0020
26 cz 4.3000
27 pz 8.6000
c ----- sweeps + 1" h2o -----
28 pz -2.5400
29 cz 6.8400 $ 4.30 + 2.54 = 6.84
30 pz 11.1400 $ 8.60 + 2.54 = 11.14
c ----- precipitate tank ----- 6.3" dia. 26" T 12 liters ----- TK-001A/B/C --
c ----- phase separator tank ----- 6.3" dia. 26" T 12 liters ----- TK-004 --
31 pz 0.0020
32 cz 8.0010
33 pz 109.6400 $ 42" x 2.54 = 106.68
c ----- precipitate tank + 1" h2o -----
c ----- phase separator tank + 1" h2o -----
34 pz -2.5401
35 cz 10.5410
36 pz 112.1800
91 pz 15.2500 $ 6" of Pu solid at bottom of 3 precipitation tanks
101 pz 15.2400 $ 6" of water surrounding the tanks
102 cz 8.1000
c ----- vacuum trap tank ----- 6.3" dia. 22" T 11.1 liters ----- TK-006 ---
37 pz 55.8800
81 pz 58.3400 $ + 1" h2o
c ----- vacuum catch tank ----- 6.3" dia. 12" T 5.5 liters ----- TK-005 ---

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c	m9	94239.55c	-0.92346	8016.50c	-0.06804	1001.50c	-0.0085	\$ 4.5 kg Pu in 5.5 g/cc
c	mt9	lwtr.01t						\$ as PuO2, rho=5.956
c	m11	26000.55c	-1.000000					\$ rho=7.84 , ss
c	m12	1001.50c	-0.076073	8016.50c	-0.608635	94239.50	-0.315286	\$ rho=1.427280, 450 g/l Pu solution
c	mt12	lwtr.01t						\$ filtrate stream
c	m13	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c	-0.500	\$ rho=1.903890, 40 wt% moisture
c	mt13	lwtr.01t						\$ Pu(OH)4 precipitate
c	m14	13027.50c	-0.212	20000.50c	-0.007	9019.50c	-0.014	\$ rho=2.010000, reflector brick zone
c		8016.50c	-0.497	12000.50c	-0.006	14000.50c	-0.252	\$
c		22000.50c	-0.012					\$ reflector brick zone
c	m15	1001.50c	-0.66666	6000.50c	-0.33334			\$ rho=0.900000, polyethylene
c	mt15	lwtr.01t						
c	m21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c	-0.850000	\$ 40 gPu/L in Pu(NO3)4
c		1001.50c	-0.103000					\$ rho=1.06327, h/x=648
c	mt21	lwtr.01t						\$ for precipitator tank
c	m22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c	-0.842000	\$ 50 gPu/L in Pu(NO3)4
c		1001.50c	-0.101000					\$ rho=1.07909, h/x=525
c	mt22	lwtr.01t						\$ for precipitator tank
c	m23	94239.55c	-0.059000	7014.50c	-0.014000	8016.50c	-0.829000	\$ 60 gPu/L in Pu(NO3)4
c		1001.50c	-0.101000					\$ rho=1.10282, h/x=397
c	mt23	lwtr.01t						\$ for precipitator tank
c	m24	94239.55c	-0.731000	8016.50c	-0.250000	1001.50c	-0.019000	\$ 3 g Pu/cc in PuO2, h/x=6.23
c	mt24	lwtr.01t						\$ rho=4.101430, floor
c	m25	94239.55c	-0.000001	8016.50c	-0.888105	1001.50c	-0.111894	\$ 10-3 g/L metal h/x=2.7e+7
c	mt25	lwtr.01t						\$ rho=1.000001, ps tank
c	m26	94239.55c	-0.465000	8016.50c	-0.482000	1001.50c	-0.853000	\$ 2.5 kg PuO2, h/x=27
c	mt26	lwtr.01t						\$ rho=1.927080, hp boat
c	m27	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ 2.5 kg PuO2 50-50 of Pu & water
c	mt27	lwtr.01t						\$ rho=1.903890, vacuum filter basin
c	m28	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ 1.5 kg, 3 g/cc h/x=7.5
c	mt28	lwtr.01t						\$ rho=3.848640, 0.5 L sweeps
c	m29	94239.55c	-0.086000	7014.50c	-0.020000	8016.50c	-0.802000	\$ 100 gPu/L in Pu(NO3)4
c		1001.50c	-0.092000					\$ rho=1.15800, h/x=256
c	mt29	lwtr.01t						\$ for precipitator tank
c	m30	94239.55c	-0.001000	8016.50c	-0.888000	1001.50c	-0.111000	\$ 1 g/L Pu, h/x=26,517
c	mt30	lwtr.01t						\$ rho=1.00100, phase separator tank
c	m31	94239.55c	-0.539000	8016.50c	-0.418000	1001.50c	-0.043000	\$ 2.75 kg PuO2, h/x=19
c	mt31	lwtr.01t						\$ rho=2.263000, boat
c	m35	94239.55c	-7.660	8016.50c	-0.38156	1001.50c	-0.048073	\$ PuN + water, rho=8.5403
c	mt35	lwtr.01t						
c	m36	4009.50	1	8016.50	1			\$ BeO, rho=3.01
c	m1	94239.55c	-0.730850	8016.50c	-0.250110	1001.50c	-0.019040	\$ rho=4.104800, qb hold up
c	mt1	lwtr.01t						
c	m2	94239.55c	-0.047700	8016.50c	-0.846500	1001.50c	-0.105800	\$ rho=1.047500, precipitate tank
c	mt2	lwtr.01t						
c	m3	94239.55c	-0.000001	8016.50c	-0.888888	1001.50c	-0.111111	\$ rho=1.000001, phase separator tank
c	mt3	lwtr.01t						
c	m4	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ rho=1.903890, vacuum filter basin
c	mt4	lwtr.01t						
c	m5	94239.55c	-0.454300	8016.50c	-0.485100	1001.50c	-0.060600	\$ rho=1.758500, hot plate boat
c	mt5	lwtr.01t						
c	m6	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ rho=3.848640, sweep can (a)
c	mt6	lwtr.01t						
c	m9	94239.55c	-0.570400	8016.50c	-0.381900	1001.50c	-0.047700	\$ rho=2.182000, sweep can (b)
c	mt9	lwtr.01t						
c	m7	7014.50c	0.790000	8016.50c	0.210000			\$ rho=1.001290, air
c	m8	1001.50c	0.66667	8016.50c	0.3333			\$ rho=1.00 , h2o
c	mt8	lwtr.01t						\$ h2o
c	m9	26000.55c	0.05536	24000.50c	0.01641	28000.50c	0.01122	\$ ss
c		25055.50c	0.00155	42000.50c	0.00126	6000.50c	0.0002003	\$ ss
c	m10	1001.50c	-0.0031	8016.50c	-0.4407	11023.50c	-0.0182	\$ Concrete
c		12000.50c	-0.0376	13027.50c	-0.0607	14000.50c	-0.2157	\$ concrete
c		15031.50c	-0.0009	16032.50c	-0.0009	36084.50c	-0.0066	\$ concrete
c		20000.50c	-0.1306	22000.50c	-0.0049	26000.55c	-0.0788	\$ concrete
c	mt10	lwtr.01t						\$ concrete
c	kcode	6000	1.0	10	600			
c	ksrc	383.53	35.56	60.96				\$ tk-001a precipitator tank
c		312.42	35.56	60.96				\$ tk-001b precipitator tank
c		233.68	35.56	60.96				\$ tk-001c precipitator tank
c		233.56	81.28	60.96				\$ tk-004 phase separator tank
c		175.26	72.39	40.64				\$ tk-005 vacuum catch tank
c		127.00	72.39	106.68				\$ tk-006 vacuum trap tank
c		388.62	72.39	96.65				\$ tl-002a polishing filter

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c      308.61 72.39 96.65
c      330.00 81.28 10.00
c      70.00 65.00 10.00
c      200.00 25.00 20.00
c      144.78 27.00 10.00
c      50.00 65.00 150.00
c      70.00 65.00 150.00
c      90.00 65.00 150.00
c      110.00 27.00 10.00
c      25.00 20.00 10.00
c      55.84 95.00 10.00
c      96.52 95.00 10.00
c      96.52 95.00 40.00
c      96.52 95.00 80.00
c      312.42 35.56 10.00
c      144.78 -10.00 10.00
c      100.00 50.00 0.15
c      200.00 50.00 0.15
c      300.00 50.00 0.15
prdmpr j -300 1 3
totnu
print 12#
ctme 360
$ fl-002b polishing filter
$ p-001 transfer pump x=312.24
$ drip pan
$ sweeps
$ fl-001 wet vacuum filter
$ fl-001 dry vacuum filter 1
$ fl-001 dry vacuum filter 2
$ fl-001 dry vacuum filter 3
$ furnace boat
$ hot plate boat
$ storage rack boat 1
$ storage rack boat 2
$ storage rack boat 3
$ storage rack boat 4
$ extra boat
$ 4.5 kg can outside of gb
$ glovebox floor holdup
$ glovebox floor holdup
$ glovebox floor holdup

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Case cc81

```

mgch glove box 3 criticality, contingency cases, cc81.i
c glovebox model and outside world,
c cc8 : double filter basin with solids: 5.5 kg
c cc81: take away 1" of 450 g/L solution at the bottom
c cc82: take 1" of surrounding water off
c cc83: take boat away
c cc84: change 6" of water density to 1/6, i.e., 0.167 g/cc
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.000000 19 -20 21 -22 23 -24 (-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 19 -18 #7 #8 #9 #56 #13 #16 #19 #20 #23 #26 #29 #35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 29 -1.15800 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 7 -1.000000 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000 -33 -32 31 u=13 imp:n=1 $ tk-004 , phase separator tank 36" t
11 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
12 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
13 30 -1.001000 -38 -32 31 u=10 imp:n=1 $ tk-005 , vacuum catch tank 12" t
14 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
15 0 -82 (-102:-101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
16 30 -1.001000 -37 -32 31 u=11 imp:n=1 $ tk-006 , vacuum trap tank 22" t
17 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
18 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c polishing filter model, 6.3" dia. 15.5" T/T
19 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
20 7 -1.000000 (-92: -32: 31) u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
21 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $ 1" of water 6" tall
c polishing filter relocation
22 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
23 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
24 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
25 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
26 30 -1.001000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
27 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
28 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
29 28 -3.84864 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
30 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
31 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
32 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
33 8 -0.00129 -41 45 -44 u=7 imp:n=1 $ 450 g/L Pu solution (air now)
34 27 -1.90389 -41 48 -49 u=7 imp:n=1 $ 5.5 kg PuO2 + 5.5 kg water
35 7 -1.000000 (41: 49:-45) u=7 imp:n=1 $ reflector brick zone
36 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
37 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
38 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
39 7 -1.000000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
40 7 -1.000000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
41 7 -1.000000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
42 7 -1.000000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
43 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
44 like 41 but trcl=14 $ dry filter 2

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43      like 41 but trcl=15 $ dry filter 3
c transition boat model
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.000000 -1: 2: -3: 4: -5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c hot plate boat model
47 31 -2.263000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84 (-7: 8: -9: 10: -11: 12) u=12 imp:n=1 $ 3/4" of ss
50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
51 like 46 but trcl=18 $ storage rack boat 1
52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 24 -4.10143 13 -14 15 -16 17 -90 imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup

c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500
2 py 6.3500 $ 5"
3 px -13.9700
4 px 13.4700 $ 11"
5 pz -3.1750
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----
7 py -8.4900
8 py 8.4900 $ 5" + 1" water
9 px -16.5100
10 px 16.5100 $ 11" + 1" water
11 pz -5.7150
12 pz 5.7150 $ 2.5" + 1" water
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510 $ 5" + 1" water
54 px -13.9710
55 px 13.9710 $ 11" + 1" water
56 pz -3.1760
57 pz 5.7150 $ 2.5" + 1" of water on top of boat only
c ----- glovebox ----- 14'x6.5'x3.5' -----
13 py 0.0000
14 py 106.6000 $ 42" ( 3.5') wide of glovebox
15 px 0.0000
16 px 426.7200 $ 168" (14.0') long of glovebox
17 pz 0.0000
18 pz 198.1200 $ 78" ( 6.5') deep of glovebox
c ----- glovebox + 12" h2o -----
19 py -30.4800 $ + 12" side (-y dir.)
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
21 px -30.4800 $ + 12" side (-x dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23 pz -15.2400 $ + 6" bottom (-z dir.)
24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- glovebox + 12" h2o -----
c 19 py -2.5401 $ + 1" side (-y dir.)
c 20 py 109.2201 $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
c 21 px -2.5401 $ + 1" side (-x dir.)
c 22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)
c 23 pz -2.5401 $ + 1" bottom (-z dir.)
c 24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- sweeps ----- 0.5 liter, 1/4"pei*d*d*h=500cc, h=d=8.6 cm, r=4.3 cm -----
25 pz 0.0020
26 cz 4.3000
27 pz 8.6000
c ----- sweeps + 1" h2o -----
28 pz -2.5400
29 cz 6.9400 $ 4.30 + 2.54 = 6.84
30 pz 11.1400 $ 8.60 + 2.54 = 11.14
c ----- precipitate tank ----- 6.3" dia. 26" T 12 liters ----- TK-001A/B/C --
c ----- phase separator tank ----- 6.3" dia. 26" T 12 liters ----- TK-004 --
31 pz 0.0020
32 cz 8.0010
33 pz 109.6400 $ 42" x 2.54 = 106.68
c ----- precipitate tank + 1" h2o -----
c ----- phase separator tank + 1" h2o -----
34 pz -2.5401
35 cz 10.5410
36 pz 112.1800
91 pz 15.2500 $ 6" of Pu solid at bottom of 3 precipitation tanks
101 pz 15.2400 $ 6" of water surrounding the tanks
192 cz 8.1000
c ----- vacuum trap tank ----- 6.3" dia. 22" T 11.1 liters ----- TK-006 ---
37 pz 55.8800
81 pz 58.3400 $ + 1" h2o
c ----- vacuum catch tank ----- 6.3" dia. 12" T 5.5 liters ----- TK-005 ---
38 pz 30.4800
82 pz 33.0200 $ + 1" h2o
c ----- polishing filter basin ----- 6.3" dia. 16" T duplex ----- FL-002A/B ---
39 pz 40.6400
83 pz 43.1200 $ + 1" h2o
c ----- vacuum filter basin ----- 17" dia. 2" deep ----- FL-001 ---
c ----- drying filter ----- 17" dia. 2" deep ----- FL-001 ---
41 cz 22.225 $ ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm filter

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42	cz	23.495	\$ OD reflector brick	(18.5"/2) * 2.54 = 23.495 cm	filter	
43	cz	26.035	\$ (20.5"/2)* 2.54 = 26.035 cm	1"of H2O surrounding the filter		
44	pz	-0.3175	\$ (.25"/2)* 2.54 = 0.3175 cm	1/4" ss		
45	pz	-2.8575	\$ x for solution	[Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm		
46	pz	-4.1275	\$ 1/2" of reflector brick	2.5875+1/2"*2.54= 4.1275 cm		
47	pz	-6.6675	\$ 1" of H2O	4.1275+ 1"*2.54= 6.6675 cm		
48	pz	0.3175	\$ (.25"/2)* 2.54 = 0.3175 cm	1/4" ss		
49	pz	4.0406	\$ y for precipitate [Pu(OH)4]	above 0.3175+1.5"*2.54= 4.0406 cm		
50	pz	5.3106	\$ 1/2" of reflector brick	4.0406+1/2"*2.54= 5.3106 cm		
51	pz	7.8506	\$ 1" of H2O	5.3106+ 1"*2.54= 7.8506 cm		
c ----- drip pan ----- 1'x1.5'x2" or 12"x18"x2" -----						
61	pk	-15.2400				
62	pk	15.2400	\$ 12"			
63	py	-22.8600				
64	py	22.8600	\$ 18"			
65	pz	-2.5400				
66	pz	2.5400	\$ 2"			
c ----- drip pan + 0.001" h2o -----						
67	py	-17.7800				
68	py	17.7800	\$ 12" + 1" water			
69	pk	-25.4000				
70	pk	25.4000	\$ 18" + 1" water			
71	pz	-5.0800				
72	pz	5.0800	\$ 2" + 1" water			
c ----- transfer pump ----- 6.7" dia. x 8" wide ----- p-001g2 -----						
73	pz	-10.1600				
74	cz	8.5090				
75	pz	10.1600				
c ----- transfer pump + 1" h2o -----						
76	pz	-10.1601				
77	cz	8.5091				
78	pz	10.1601				
c ----- boat + 1" water + 3/4" ss -----						
84	py	-10.7950				
85	py	10.7950	\$ 5" + 1" water + 3/4" ss			
86	pk	-18.4150				
87	pk	18.4150	\$ 11" + 1" water + 3/4" ss			
88	pz	-7.6200				
89	pz	7.6200	\$ 2.5" + 1" water + 3/4" ss			
c -----						
90	pz	0.3175	\$ 1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup			
92	pz	20.3200	\$ half of polishing filter height of 16"			
100	so	600.000	\$ sphere for outside world boundary			
tr1	383.53	35.56	60.96	\$ tk-001a	precipitator tank	
tr2	312.42	35.56	60.96	\$ tk-001b	precipitator tank	
tr3	233.68	35.56	60.96	\$ tk-001c	precipitator tank	
tr4	233.56	81.28	60.96	\$ tk-004	phase separator tank	
tr5	175.26	72.39	40.64	\$ tk-005	vacuum catch tank	
tr6	127.00	72.39	106.68	\$ tk-006	vacuum trap tank	
tr7	388.62	72.39	96.52	\$ fl-002a	polishing filter	
tr8	308.61	72.39	96.52	\$ fl-002b	polishing filter	
tr9	330.00	81.28	20.00	\$ p-001	transfer pump x=312.24	
tr10	70.00	65.00	10.00	\$	drip pan	
tr11	200.00	25.00	10.00	\$	sweeps	
tr12	144.78	27.00	10.00	\$ fl-001	wet vacuum filter	
*tr13	50.00	65.00	150.00	\$ fl-001	dry vacuum filter 1	
*tr14	70.00	65.00	150.00	\$ fl-001	dry vacuum filter 2	
*tr15	90.00	65.00	150.00	\$ fl-001	dry vacuum filter 3	
*tr16	110.00	27.00	10.00	\$	furnace boat	
tr17	25.00	20.00	10.00	\$	hot plate boat	
tr18	55.88	95.00	10.00	\$	storage rack boat 1	
tr19	96.52	95.00	10.00	\$	storage rack boat 2	
c	tr20	96.52	95.00	40.00	\$	storage rack boat 3
c	tr21	96.52	95.00	80.00	\$	storage rack boat 4
*tr22	312.42	35.56	10.00	\$	extra boat	
mode n						
c -----						
m7		8016.50c	-0.888889	1001.50c	-0.111111 \$ rho=1.000000, water	
mt7	lwtr.01t					
c -----						
m8		8016.50c	-0.235000	7014.50c	-0.765000 \$ rho=0.001290, air	
c -----						
m11	26000.55c	-1.000000			\$ rho=7.84 , ss	
c -----						
m12	1001.50c	-0.076079	8016.50c	-0.608635	94239.50 -0.315286 \$ rho=1.427280, 450 g/l Pu solution	
mt12	lwtr.01t				\$ filtrate stream	
c -----						
m13	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c -0.500 \$ rho=1.903890, 40 wt% moisture	
mt13	lwtr.01t				\$ Pu(OH)4 precipitate	
c -----						
m14	13027.50c	-0.212	20000.50c	-0.007	9019.50c -0.014 \$ rho=2.010000, reflector brick zone	
	8016.50c	-0.497	12000.50c	-0.006	14000.50c -0.252 \$	
	22000.50c	-0.012			\$ reflector brick zone	
c -----						
m15	1001.50c	-0.66666	6000.50c	-0.33334	\$ rho=0.900000, polyethylene	
mt15	lwtr.01t					
c -----						
m21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c -0.850000 \$ 40 gPu/L in Pu(NO3)4	
	1001.50c	-0.103000			\$ rho=1.06327, h/x=648	
mt21	lwtr.01t				\$ for precipitator tank	
c -----						
m22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c -0.842000 \$ 50 gPu/L in Pu(NO3)4	
	1001.50c	-0.101000			\$ rho=1.07909, h/x=525	
mt22	lwtr.01t				\$ for precipitator tank	

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c
m23 94239.55c -0.059000 7074.50c -0.014000 8016.50c -0.829000 $ 60 gPu/L in Pu(NO3)4
      1001.50c -0.101300 $ rho=1.10282, h/x=397
      lwtr.01t $ for precipitator tank
c
m24 94239.55c -0.731000 8016.50c -0.250000 1001.50c -0.019000 $ 3 g Pu/cc in PuO2, h/x=6.23
      lwtr.01t $ rho=4.101430, floor
c
m25 94239.55c -0.000001 8016.50c -0.888105 1001.50c -0.111894 $ 10-3 g/L metal h/x=2.7e+7
      lwtr.01t $ rho=1.000001, ps tank
c
m26 94239.55c -0.465000 8016.50c -0.482000 1001.50c -0.053000 $ 2.5 kg PuO2, h/x=27
      lwtr.01t $ rho=1.927040, hp boat
c
m27 94239.55c -0.500000 8016.50c -0.444400 1001.50c -0.055600 $ 2.5 kg PuO2 50-50 of Pu & water
      lwtr.01t $ rho=1.903890, vacuum filter basin
c
m28 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ 1.5 kg, 3 g/cc h/x=7.5
      lwtr.01t $ rho=3.848640, 0.5 L sweeps
c
m29 94239.55c -0.086000 7074.50c -0.020000 8016.50c -0.802000 $ 100 gPu/L in Pu(NO3)4
      1001.50c -0.092000 $ rho=1.15800, h/x=256
      lwtr.01t $ for precipitator tank
c
m30 94239.55c -0.001000 8016.50c -0.888000 1001.50c -0.111000 $ 1 g/L Pu, h/x=26,517
      lwtr.01t $ rho=1.00100, phase separator tank
c
m31 94239.55c -0.539000 8016.50c -0.418000 1001.50c -0.043000 $ 2.75 kg PuO2, h/x=19
      lwtr.01t $ rho=2.263000, boat
c
c m1 94239.55c -0.730850 8016.50c -0.250110 1001.50c -0.019040 $ rho=4.104800, gb hold up
      lwtr.01t
c
c m2 94239.55c -0.047700 8016.50c -0.846500 1001.50c -0.105800 $ rho=1.047500, precipitate tank
      lwtr.01t
c
c m3 94239.55c -0.000001 8016.50c -0.888888 1001.50c -0.111111 $ rho=1.000001, phase separator tank
      lwtr.01t
c
c m4 94239.55c -0.500000 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
      lwtr.01t
c
c m5 94239.55c -0.454300 8016.50c -0.485100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
      lwtr.01t
c
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
      lwtr.01t
c
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
      lwtr.01t
c
c m7 7074.50c 0.790000 8016.50c 0.210000 $ rho=1.001290, air
c
c m8 1001.50c 0.66667 8016.50c 0.3333 $ rho=1.00, h2o
      lwtr.01t $ h2o
c
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
      25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c
c m10 1001.50c 0.00031 8016.50c -0.4407 11023.50c -0.0182 $ Concrete
      12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
      15031.50c -0.0009 16032.50c -0.0009 36084.50c -0.0066 $ concrete
      20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788 $ concrete
      lwtr.01t $ concrete
kcode 6000 1.0 10 600
ksrc 383.53 35.56 60.96 $ tk-001a precipitator tank
      312.42 35.56 60.96 $ tk-001b precipitator tank
      233.68 35.56 60.96 $ tk-001c precipitator tank
      233.56 81.28 60.96 $ tk-004 phase separator tank
      175.26 72.39 40.64 $ tk-005 vacuum catch tank
      127.00 72.39 106.68 $ tk-006 vacuum trap tank
      388.62 72.39 96.65 $ fl-002a polishing filter
      308.61 72.39 96.65 $ fl-002b polishing filter
      330.00 81.28 10.00 $ p-001 transfer pump x=312.24
      70.00 65.00 10.00 $
      200.00 25.00 20.00 $ drip pan
      144.78 27.00 10.00 $ sweeps
      50.00 65.00 150.00 $ fl-001 wet vacuum filter
      70.00 65.00 150.00 $ fl-001 dry vacuum filter 1
      90.00 65.00 150.00 $ fl-001 dry vacuum filter 2
      110.00 27.00 10.00 $ fl-001 dry vacuum filter 3
      25.00 20.00 10.00 $ furnace boat
      55.88 95.00 10.00 $ hot plate boat
      96.52 95.00 10.00 $ storage rack boat 1
      96.52 95.00 40.00 $ storage rack boat 2
      96.52 95.00 80.00 $ storage rack boat 3
      312.42 35.56 10.00 $ storage rack boat 4
      100.00 50.00 0.15 $ glovebox floor holdup
      200.00 50.00 0.15 $ glovebox floor holdup
      300.00 50.00 0.15 $ glovebox floor holdup
prdnm j -300 1 3
totnu
print 128
ctme 360

```

Case ccs

```

mgob glove box 3 criticality, contingency cases, ccs.1
c glovebox model and outside world,
c fill filter basin with 2 g/cc PuO2
1 0 100
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=0 $ outside world
3 7 -1.00000 19 -20 21 -22 23 -24 imp:n=1 $ outside glovebox

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(-13: 14:-15: 16:-17: 18)      imp:n=1 $ 12" side 6" bottom 1" top
4  9 -0.00129      13 -14 15 -16 19 -18 #7 #8 #9
      #56 #13 #16 #19 #20 #23 #26 #29
      #35 #41 #42 #43 #46 #50 #51 #52 #53 imp:n=1 $ inside glovebox
c  tank model,(Pu)      6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5  29 -1.15800      -33 -32 31      u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57 24 -4.10143      -91 -32 31      u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6  7 -1.00000      (33: 32:-31)      u=2 imp:n=1 $ 1" of surrounding water 6" high
7  0      -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c  tank relocations (Pu)
8      like 7 but trcl=2      $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9      like 7 but trcl=3      $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c  tank model,(Pu)      6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000      -33 -32 31      u=3 imp:n=1 $ tk-004, phase separator tank 36" t
55 7 -1.000000      (33: 32:-31)      u=13 imp:n=1 $ 1" of water 6" tall
56 0      -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c  tank model,(Pu)      6.3" dia. 12.0" T/T, 5.5 liters
11 30 -1.001000      -38 -32 31      u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12 7 -1.000000      (38: 32:-31)      u=10 imp:n=1 $ 1" of water 6" tall
13 0      -82 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c  tank model,(Pu)      6.3" dia. 22.0" T/T, 11.1 liters
14 30 -1.001000      -37 -32 31      u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t
15 7 -1.000000      (37: 32:-31)      u=11 imp:n=1 $ 1" water 6" tall
16 0      -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c  polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000      -39 -32 32      u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000      -92 -32 31      u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000      (39: 32:-31)      u=3 imp:n=1 $ 1" of water 6" tall
19 0      -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c  polishing filter relocation
20      like 19 but trcl=8      $ fl-002b, polishing filter 16" t
c  transfer pump model
21 30 -1.001000      -75 -74 73      u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000      (75: 74:-73)      u=4 imp:n=1 $ 1" of water 6" tall
23 0      -78 -77 76      trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c  drip pan model
24 30 -1.001000      61 -62 63 -64 65 -66      u=5 imp:n=1 $ water in drip pan
25 7 -1.000000      (-61: 62:-63: 64:-65: 66)      u=5 imp:n=1 $ 1" of water around
26 0      67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c  sweeps model
27 28 -3.84864      -27 -26 25      u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000      (27: 26:-25)      u=6 imp:n=1 $ air
29 0      -33 -29 28      trcl=11 fill=6 imp:n=1 $
c  wet filter model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84      -41 44 -48      u=7 imp:n=1 $ 25 micron filter (ss)
31 12 -1.42728      -41 45 -44      u=7 imp:n=1 $ 450 g/l Pu solution (air for normal cond.)
32 33 -3.07000      -41 48 -49      u=7 imp:n=1 $ fill basin with 2g/cc PuO2
33 7 -1.000000      (41: 49:-45)      u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000      42 -46 50      u=7 imp:n=1 $ 1" of water surrounding
35 0      -43 47 -51      trcl=12 fill=7 imp:n=1 $
c  dry filter model
36 11 -7.84      -41 44 -48      u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.000000      -41 45 -44      u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.000000      -41 48 -49      u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.000000      (41: 49:-45)      u=8 imp:n=1 $ reflector brick zone
40 7 -1.000000      42 -46 50      u=8 imp:n=1 $ 1" of water surrounding
41 0      -43 47 -51      trcl=13 fill=8 imp:n=1 $
c  dry filter model
42      like 41 but trcl=14      $ dry filter 2
43      like 41 but trcl=15      $ dry filter 3
c  transition boat model
44 31 -2.263000      1 -2 3 -4 5 -6      u=9 imp:n=1 $ furnace boat 2.75 kg
45 7 -1.000000      (-1: 2:-3: 4:-5: 6)      u=9 imp:n=1 $ 1" of water on top
46 0      52 -53 54 -55 56 -57 trcl=16 fill=9 imp:n=1 $
c  hot plate boat model
47 31 -2.263000      1 -2 3 -4 5 -6      u=12 imp:n=1 $ hot plate boat 2.75 kg
48 15 -0.900000      7 -8 9 -10 11 -12 #47      u=12 imp:n=1 $ 1" of polyethylene
49 11 -7.84      (-7: 8:-9: 10:-11: 12)      u=12 imp:n=1 $ 3/4" of ss
50 0      #4 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c  transition boat relocations
51      like 46 but trcl=18      $ storage rack boat 1
52      like 46 but trcl=19      $ storage rack boat 2
c      46      like 46 but trcl=20      $ storage rack boat 3
c      47      like 46 but trcl=21      $ storage rack boat 4
53      like 46 but trcl=22      $ extra boat
c  1/8" thick layer of holdup in glove box
54 24 -4.10143      13 -14 15 -16 17 -90      imp:n=1 $ 3 g Pu/cc as PuO2 on floor as holdup
c  ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1  py -6.3500      $ 5"
2  py 6.3500      $ 5"
3  px -13.9700      $ 11"
4  px 13.9700      $ 11"
5  pz -3.1750      $ 2.5"
6  pz 3.1750      $ 2.5"
c  ----- boat + 1" h2o -----
7  py -8.8900
8  py 8.8900      $ 5" + 1" water
9  px -16.5100
10 px 16.5100      $ 11" + 1" water
11 pz -5.7150
12 pz 5.7150      $ 2.5" + 1" water
c  ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510      $ 5" + 1" water

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54	px	-13.9710				
55	px	13.9710	\$	11" + 1" water		
56	pz	-3.1760				
57	pz	5.7150	\$	2.5" + 1" of water on top of boat only		
c	-----	glovebox	-----	14'x6.5'x3.5'	-----	
13	py	0.0000				
14	py	106.6800	\$	42" (3.5') wide of glovebox		
15	px	0.0000				
16	px	426.7200	\$	168" (14.0') long of glovebox		
17	pz	0.0000				
18	pz	198.1200	\$	78" (6.5') deep of glovebox		
c	-----	glovebox + 12" h2o	-----		-----	
19	py	-30.4800	\$		+ 12" side (-y dir.)	
20	py	137.1600	\$	42" (3.5') wide of glovebox	+ 12" side (+y dir.)	
21	px	-30.4800	\$		+ 12" side (-x dir.)	
22	px	457.2000	\$	168" (14.0') long of glovebox	+ 12" side (+x dir.)	
23	pz	-15.2400	\$		+ 6" bottom (-z dir.)	
24	pz	200.6600	\$	78" (6.5') deep of glovebox	+ 1" roof (+z dir.)	
c	-----	glovebox + 12" h2o	-----		-----	
c	19	py	-2.5401	\$	+ 1" side (-y dir.)	
c	20	py	109.2201	\$	42" (3.5') wide of glovebox	+ 1" side (+y dir.)
c	21	px	-2.5401	\$	+ 1" side (-x dir.)	
c	22	px	429.2601	\$	168" (14.0') long of glovebox	+ 1" side (+x dir.)
c	23	pz	-2.5401	\$	+ 1" bottom (-z dir.)	
c	24	pz	200.6600	\$	78" (6.5') deep of glovebox	+ 1" roof (+z dir.)
c	-----	sweeps	-----	0.5 liter, 1/4"pei*d*h=500cc, h=d=8.6 cm, r=4.3 cm	-----	
25	pz	0.0020				
26	cz	4.3000				
27	pz	8.6000				
c	-----	sweeps + 1" h2o	-----		-----	
28	pz	-2.5400				
29	cz	6.8400	\$	4.30 + 2.54 = 6.84		
30	pz	11.1400	\$	8.60 + 2.54 = 11.14		
c	-----	precipitate tank	-----	6.3" dia. 26" T 12 liters	TK-001A/B/C	
c	-----	phase separator tank	-----	6.3" dia. 26" T 12 liters	TK-004	
31	pz	0.0020				
32	cz	8.0010				
33	pz	109.6400	\$	42" x 2.54 = 106.68		
c	-----	precipitate tank + 1" h2o	-----		-----	
c	-----	phase separator tank + 1" h2o	-----		-----	
34	pz	-2.5401				
35	cz	10.5410				
36	pz	112.1300				
91	pz	15.2500	\$	6" of Pu solid at bottom of 3 precipitation tanks		
101	pz	15.2400	\$	6" of water surrounding the tanks		
102	cz	8.1000				
c	-----	vacuum trap tank	-----	6.3" dia. 22" T 11.1 liters	TK-006	
37	pz	55.8800				
81	pz	58.3400	\$	+ 1" h2o		
c	-----	vacuum catch tank	-----	6.3" dia. 12" T 5.5 liters	TK-005	
38	pz	30.4800				
82	pz	33.0200	\$	+ 1" h2o		
c	-----	polishing filter basin	-----	6.3" dia. 16" T duplex	FL-002A/B	
39	pz	40.6400				
83	pz	43.1800	\$	+ 1" h2o		
c	-----	vacuum filter basin	-----	17" dia. 2" deep	FL-001	
c	-----	drying filter	-----	17" dia. 3" deep	FL-001	
41	cz	22.225	\$	ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm	filter	
42	cz	23.495	\$	OD reflector brick (18.5"/2) * 2.54 = 23.495 cm	filter	
43	cz	26.035	\$	(20.5"/2) * 2.54 = 26.035 cm 1" of H2O surrounding the filter		
44	pz	-0.3175	\$	(.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
45	pz	-2.8575	\$	x for solution [Mg(NO3)2] below 0.3175+ 1" * 2.54 = 2.8575 cm		
46	pz	-4.1275	\$	1/2" of reflector brick 2.8575+1/2" * 2.54 = 4.1275 cm		
47	pz	-6.6675	\$	1" of H2O 4.1275+ 1" * 2.54 = 6.6675 cm		
48	pz	0.3175	\$	(.25"/2) * 2.54 = 0.3175 cm 1/4" ss		
49	pz	2.8575	\$	y for precipitate [Pu(OH)4] above 0.3175+2.0" * 2.54 = 2.8575 cm		
50	pz	4.1275	\$	1/2" of reflector brick 2.8575+1/2" * 2.54 = 4.1275 cm		
51	pz	6.6675	\$	1" of H2O 4.1275+ 1" * 2.54 = 6.6675 cm		
c	-----	drip pan	-----	1'x1.5'x2" or 12"x18"x2"	-----	
61	px	-15.2400				
62	px	15.2400	\$	12"		
63	py	-22.8600				
64	py	22.8600	\$	18"		
65	pz	-2.5400				
66	pz	2.5400	\$	2"		
c	-----	drip pan + 0.001" h2o	-----		-----	
67	py	-17.7800				
68	py	17.7800	\$	12" + 1" water		
69	px	-25.4000				
70	px	25.4000	\$	18" + 1" water		
71	pz	-5.0800				
72	pz	5.0800	\$	2" + 1" water		
c	-----	transfer pump	-----	6.7" dia. x 8" wide	p-00142	
73	pz	-10.1600				
74	cz	8.5090				
75	pz	10.1600				
c	-----	transfer pump + 1" h2o	-----		-----	
76	pz	-10.1601				
77	cz	8.5091				
78	pz	10.1601				
c	-----	boat + 1" water + 3/4" ss	-----		-----	
84	py	-10.7950				
85	py	10.7950	\$	5" + 1" water + 3/4" ss		
86	px	-18.4150				

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87	px	18.4150	\$	11" + 1" water + 3/4" ss			
88	pz	-7.6200					
89	pz	7.6200	\$	2.5" + 1" water + 3/4" ss			
c							
90	pz	0.3175	\$	1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup			
92	pz	20.3200	\$	half of polishing filter height of 16"			
100	so	600.000	\$	sphere for outside world boundary			
tr1	383.53	35.56	60.96	\$ tk-001a	precipitator	tank	
tr2	312.42	35.56	60.96	\$ tk-001b	precipitator	tank	
tr3	233.68	35.56	60.96	\$ tk-001c	precipitator	tank	
tr4	233.56	81.28	60.96	\$ tk-004	phase separator	tank	
tr5	175.26	72.39	40.64	\$ tk-005	vacuum catch	tank	
tr6	127.00	72.39	106.68	\$ tk-006	vacuum trap	tank	
tr7	388.62	72.39	96.52	\$ fl-002a	polishing	filter	
tr8	308.61	72.39	96.52	\$ fl-002b	polishing	filter	
tr9	330.00	81.28	20.00	\$ p-001	transfer	pump x=312.24	
tr10	70.00	65.00	10.00	\$		drip pan	
tr11	200.00	25.00	10.00	\$		sweeps	
tr12	144.78	27.00	10.00	\$ fl-001	wet vacuum	filter	
*tr13	50.00	65.00	150.00	90 90 0 90 0 90 180 90 90	\$ fl-001	dry vacuum filter 1	
*tr14	70.00	65.00	150.00	90 90 0 90 0 90 180 90 90	\$ fl-001	dry vacuum filter 2	
*tr15	90.00	65.00	150.00	90 90 0 90 0 90 180 90 90	\$ fl-001	dry vacuum filter 3	
*tr16	110.00	27.00	10.00	90 0 90 180 90 90 90 90 0	\$	furnace boat	
tr17	25.00	20.00	10.00	\$	hot plate	boat	
tr18	55.88	95.00	10.00	\$	storage	rack boat 1	
tr19	96.52	95.00	10.00	\$	storage	rack boat 2	
c	tr20	96.52	95.00	40.00	\$	storage rack boat 3	
c	tr21	96.52	95.00	80.00	\$	storage rack boat 4	
*tr22	312.42	35.56	10.00	\$		extra boat	
mode	n						
c							
n7		8016.50c	-0.888889	1001.50c	-0.111111	\$ rho=1.000000, water	
mt7	lwtr.01t						
c							
na8		8016.50c	-0.235000	7014.50c	-0.765000	\$ rho=0.001290, air	
c							
ml1	26000.55c	-1.000000				\$ rho=7.84 , ss	
c							
ml2	1001.50c	-0.076079	8016.50c	-0.608635	94239.50	-0.315286	\$ rho=1.427280, 450 g/l Pu solution
mt12	lwtr.01t						\$ filtrate stream
c							
ml3	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c	-0.500	\$ rho=1.903890, 40 wt% moisture
mt13	lwtr.01t						\$ Pu(OH)4 precipitate
c							
ml4	13027.50c	-0.212	20000.50c	-0.007	9019.50c	-0.014	\$ rho=2.010000, reflector brick zone
c							
ml5	8016.50c	-0.437	12000.50c	-0.006	14000.50c	-0.252	\$ rho=1.903890, vacuum filter basin
c							
ml15	22000.50c	-0.012					\$ rho=1.927080, hp boat
c							
ml15	1001.50c	-0.66666	6000.50c	-0.33334			\$ rho=0.900000, polyethylene
mt15	lwtr.01t						
c							
ml21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c	-0.850000	\$ 40 gPu/L in Pu(NO3)4
c							
ml21	1001.50c	-0.103000					\$ rho=1.06327, h/x=648
mt21	lwtr.01t						\$ for precipitator tank
c							
ml22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c	-0.842000	\$ 50 gPu/L in Pu(NO3)4
c							
ml22	1001.50c	-0.101000					\$ rho=1.07909, h/x=525
mt22	lwtr.01t						\$ for precipitator tank
c							
ml23	94239.55c	-0.059000	7014.50c	-0.014000	8016.50c	-0.829000	\$ 60 gPu/L in Pu(NO3)4
c							
ml23	1001.50c	-0.101000					\$ rho=1.10282, h/x=397
mt23	lwtr.01t						\$ for precipitator tank
c							
ml24	94239.55c	-0.731000	8016.50c	-0.250000	1001.50c	-0.019000	\$ 3 g Pu/cc in PuO2, h/x=6.23
mt24	lwtr.01t						\$ rho=4.101430, floor
c							
ml25	94239.55c	-0.000001	8016.50c	-0.888105	1001.50c	-0.111894	\$ 10-3 g/L metal h/x=2.7e+7
mt25	lwtr.01t						\$ rho=1.000001, ps tank
c							
ml26	94239.55c	-0.465000	8016.50c	-0.482000	1001.50c	-0.053000	\$ 2.5 kg PuO2 , h/x=27
mt26	lwtr.01t						\$ rho=1.927080, hp boat
c							
ml27	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ 2.5 kg PuO2 50-50 of Pu & water
mt27	lwtr.01t						\$ rho=1.903890, vacuum filter basin
c							
ml28	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ 1.5 kg, 3 g/cc h/x=7.5
mt28	lwtr.01t						\$ rho=3.848640, 0.5 L sweeps
c							
ml29	94239.55c	-0.086000	7014.50c	-0.020000	8016.50c	-0.802000	\$ 100 gPu/L in Pu(NO3)4
c							
ml29	1001.50c	-0.092000					\$ rho=1.15800, h/x=256
mt29	lwtr.01t						\$ for precipitator tank
c							
ml30	94239.55c	-0.001000	8016.50c	-0.888000	1001.50c	-0.111000	\$ 1 g/L Pu, h/x=26,517
mt30	lwtr.01t						\$ rho=1.00100, phase separator tank
c							
ml31	94239.55c	-0.539000	8016.50c	-0.418000	1001.50c	-0.043000	\$ 2.75 kg PuO2, h/x=19
mt31	lwtr.01t						\$ rho=2.263000, boat
c							
ml33	94239.55c	-0.625000	8016.50c	-0.319000	1001.50c	-0.029000	\$ 2 g Pu/cc in PuO2, h/x=11
mt33	lwtr.01t						\$ rho=3.070000, floor
c							
ml1	94239.55c	-0.730850	8016.50c	-0.250110	1001.50c	-0.019040	\$ rho=4.104800, qb hold up
mt1	lwtr.01t						
c							

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c m2 94239.55c -0.047700 8016.50c -0.846500 1001.50c -0.105800 $ rho=1.047500, precipitate tank
c mt2 lwtr.01t
c m3 94239.55c -0.000001 8016.50c -0.888888 1001.50c -0.111111 $ rho=1.000001, phase separator tank
c mt3 lwtr.01t
c m4 94239.55c -0.500300 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
c mt4 lwtr.01t
c m5 94239.55c -0.454300 8016.50c -0.485100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
c mt5 lwtr.01t
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
c mt6 lwtr.01t
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
c mt9 lwtr.01t
c m7 7014.50c 0.790600 8016.50c 0.210000 $ rho=1.001290, air
c m8 1001.50c 0.66667 8016.50c 0.3333 $ rho=1.00, h2o
c mt8 lwtr.01t $ h2o
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
c 25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c m10 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 $ Concrete
c 12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
c 15031.50c -0.0909 16032.50c -0.0009 36084.50c -0.0066 $ concrete
c 20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788 $ concrete
c mt10 lwtr.01t $ concrete
kcode 6000 1.0 10 600
kerc 383.53 35.56 60.96 $ tk-001a precipitator tank
312.42 35.56 60.96 $ tk-001b precipitator tank
233.68 35.56 60.96 $ tk-001c precipitator tank
233.56 81.28 60.96 $ tk-004 phase separator tank
175.26 72.39 40.64 $ tk-005 vacuum catch tank
127.00 72.39 106.68 $ tk-006 vacuum trap tank
388.62 72.39 96.65 $ fl-002a polishing filter
304.61 72.39 96.65 $ fl-002b polishing filter
330.00 81.28 10.00 $ p-001 transfer pump x=312.24
70.00 65.00 10.00 $ drip pan
200.00 25.00 20.00 $ sweeps
144.78 27.00 10.00 $ fl-001 wet vacuum filter
50.00 65.00 150.00 $ fl-001 dry vacuum filter 1
70.00 65.00 150.00 $ fl-001 dry vacuum filter 2
90.00 65.00 150.00 $ fl-001 dry vacuum filter 3
110.00 27.00 10.00 $ furnace boat
25.00 20.00 10.00 $ hot plate boat
55.88 95.00 10.00 $ storage rack boat 1
96.52 95.00 10.00 $ storage rack boat 2
96.52 95.00 40.00 $ storage rack boat 3
96.52 95.00 80.00 $ storage rack boat 4
312.42 35.56 10.00 $ extra boat
100.00 50.00 0.15 $ glovebox floor holdup
200.00 50.00 0.15 $ glovebox floor holdup
300.00 50.00 0.15 $ glovebox floor holdup
prdmnp j -300 1 3
totnu
print 128
ctme 360

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Case cwcc7.i

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mqoh glove box 3 criticality, contingency cases, cwcc7.i
c glovebox model and outside world,
c seismic - base + sprinklers + break tanks, 3 precipitator tanks are empty except 6" of solid
c add a bottom cell (cell 59) into negative z dir. suggested by Carol (to avoid partial merged (sink) components)
c back to the plunging geometry, cc51: water
c cc52: 250 g Pu/L solution on floor
c cc53: take 1" of 450 g/L Pu solution at filter basin away
c collective wisdom model design to bound all the aggregate of unspaced containers
c cwcc2: upper basin boat material
c cwcc3: lower basin boat material
c cwcc4: change floor water (cell 54) to air
c cwcc5: upper and lower are all boat model (m31), zone1 had zone 2 are m32, 1" reflection
c cwcc6: lower basin become water
c cwcc7: put zone 1 back to m31
1 0 100 imp:n=0 $ outside world
2 8 -0.00129 (-19: 20:-21: 22:-23: 24) -100 imp:n=1 $ outside glovebox
3 7 -1.00000 19 -20 21 -22 23 -24 (-13: 14:-15: 16:-17: 18) imp:n=1 $ 12" side 6" bottom 1" top
4 8 -0.00129 13 -14 15 -16 93 -14 #7 #8 #9 #56 #13 #16 #19 #20 #23 #41 #42 #43 imp:n=1 $ inside glovebox
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters capacity, 12 liter for normal case
5 29 -1.15800 -33 -32 91 u=2 imp:n=1 $ tk-001a, pre. tank 100 g/L Pu(NO3)4
57 24 -4.10143 -91 -32 31 u=2 imp:n=1 $ 6" of Pu solid at bottom of 3 precipitation tanks
6 8 -0.00129 (33: 32:-31) u=2 imp:n=1 $ 1" of surrounding water 6" high
7 0 -36 (-102:-101) -35 34 trcl=1 fill=2 imp:n=1 $
c tank relocations (Pu)
8 like 7 but trcl=2 $ tk-001b, pre. tank 40 g/L Pu(NO3)4
9 like 7 but trcl=3 $ tk-001c, pre. tank 40 g/L Pu(NO3)4
c tank model, (Pu) 6.3" dia. 36.0" T/T, 20 liters
10 30 -1.001000 -33 -32 31 u=13 imp:n=1 $ tk-004, phase separator tank 36" t
55 7 -1.000000 (33: 32:-31) u=13 imp:n=1 $ 1" of water 6" tall
56 0 -36 (-102:-101) -35 34 trcl=4 fill=13 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 12.0" T/T, 5.5 liters
11 30 -1.001000 -38 -32 31 u=10 imp:n=1 $ tk-005, vacuum catch tank 12" t
12 7 -1.000000 (38: 32:-31) u=10 imp:n=1 $ 1" of water 6" tall
13 0 -42 (-102:101) -35 34 trcl=5 fill=10 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c tank model, (Pu) 6.3" dia. 22.0" T/T, 11.1 liters
14 30 -1.001000 -37 -32 31 u=11 imp:n=1 $ tk-006, vacuum trap tank 22" t

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15 7 -1.000000 (37: 32:-31) u=11 imp:n=1 $ 1" water 6" tall
16 0 -81 (-102:-101) -35 34 trcl=6 fill=11 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c polishing filter model, 6.3" dia. 15.5" T/T
17 30 -1.001000 -39 -32 92 u=3 imp:n=1 $ fl-002a, polishing filter 16" t
58 30 -1.001000 -92 -32 31 u=3 imp:n=1 $ half full of 1 g/L Pu metal, h/x=26,517
18 7 -1.000000 (39: 32:-31) u=3 imp:n=1 $ 1" of water 6" tall
19 0 -83 (-102:-101) -35 34 trcl=7 fill=3 imp:n=1 $
c polishing filter relocation
20 like 19 but trcl=8 $ fl-002b, polishing filter 16" t
c transfer pump model
21 30 -1.001000 -75 -74 73 u=4 imp:n=1 $ pu in transfer pump
22 7 -1.000000 (75: 74:-73) u=4 imp:n=1 $ 1" of water 6" tall
23 0 -78 -77 76 trcl=9 fill=4 imp:n=1 $ 1 g/L Pu metal, h/x=26,517
c drip pan model
24 7 -1.000000 61 -62 63 -64 65 -66 u=5 imp:n=1 $ water in drip pan
25 7 -1.000000 (-61: 62:-63: 64:-65: 66) u=5 imp:n=1 $ 1" of water around
26 0 67 -68 69 -70 71 -72 trcl=10 fill=5 imp:n=1 $
c sweeps model
27 7 -1.000000 -27 -26 25 u=6 imp:n=1 $ 1.5 kg, 3 g/cc, h/x=7.5
28 7 -1.000000 (27: 26:-25) u=6 imp:n=1 $ air
29 0 -30 -29 28 trcl=11 fill=6 imp:n=1 $
c wet filter basin model, height of 2.5 kg Pu and 2.5 kg water = 0.6663"
30 11 -7.84 -41 44 -48 u=7 imp:n=1 $ 25 micron filter (ss)
31 7 -1.000000 -41 45 -44 u=7 imp:n=1 $ 450 g/L Pu solution (air for normal cond.)
32 31 -2.263000 -41 48 -49 u=7 imp:n=1 $ 2.75 kg PuO2 + 2.75 kg water
61 31 -2.263000 41 -111 45 -113 u=7 imp:n=1 $ zone 1, boat zone
62 32 -1.395500 111 -112 45 -113 u=7 imp:n=1 $ zone 2, miscellaneous zone
63 31 -2.263000 -41 49 -113 u=7 imp:n=1 $ artificial zone
33 7 -1.000000 (112:113:-45) u=7 imp:n=1 $ reflector brick zone
34 7 -1.000000 42 -46 50 u=7 imp:n=1 $ 1" of water surrounding
35 0 -43 47 -51 trcl=12 fill=7 imp:n=1 $
c dry filter model
36 11 -7.84 -41 44 -48 u=8 imp:n=1 $ 25 micron filter (ss)
37 7 -1.000000 -41 45 -44 u=8 imp:n=1 $ water, bound by 1/8" of hold up
38 7 -1.000000 -41 48 -49 u=8 imp:n=1 $ water, bound by 1/8" of hold up
39 7 -1.000000 (41: 49:-45) u=8 imp:n=1 $ reflector brick zone
40 7 -1.000000 42 -46 50 u=8 imp:n=1 $ 1" of water surrounding
41 0 -43 47 -51 trcl=13 fill=8 imp:n=1 $
c dry filter model
42 like 41 but trcl=14 $ dry filter 2
43 like 41 but trcl=15 $ dry filter 3
c change basin boat to hot plate boat model for sinking reason
44 31 -2.263000 1 -2 3 -4 5 -6 u=9 imp:n=1 $ basin boat 2.75 kg
45 7 -1.000000 (-1: 2:-3: 4:-5: 6) u=9 imp:n=1 $ 1" of water on top
46 0 52 -53 54 -55 56 -57 trcl=17 fill=9 imp:n=1 $
c hot plate boat model
c 47 7 -1.000000 1 -2 3 -4 5 -6 u=12 imp:n=1 $ hot plate boat 2.75 kg (water now)
c 48 15 -0.300000 7 -8 9 -10 11 -12 #47 u=12 imp:n=1 $ 1" of polyethylene
c 49 11 -7.84 (-7: 8:-9: 10:-11: 12) u=12 imp:n=1 $ 3/4" of ss
c 50 0 84 -85 86 -87 88 -89 trcl=17 fill=12 imp:n=1 $
c transition boat relocations
c 51 like 46 but trcl=18 $ storage rack boat 1
c 52 like 46 but trcl=19 $ storage rack boat 2
c 46 like 46 but trcl=20 $ storage rack boat 3
c 47 like 46 but trcl=21 $ storage rack boat 4
c 53 like 46 but trcl=22 $ extra boat
c 1/8" thick layer of holdup in glove box
54 8 -0.00129 13 -14 15 -16 17 -93
#26 #29 #35 #46 #52 #53
c 59 34 -1.02970 13 -14 15 -16 90 -93 imp:n=1 $ 250 g Pu/L as Pu(NO3)4 solution on floor
imp:n=1 $ bottom cell for tank leak

c ----- boat ----- 11"x5"x2.5", 2.3 liters -----
1 py -6.3500
2 py 6.3500 $ 5"
3 px -13.9700
4 px 13.9700 $ 11"
5 pz -3.1750
6 pz 3.1750 $ 2.5"
c ----- boat + 1" h2o -----
7 py -8.8900
8 py 8.8900 $ 5" + 1" water
9 px -16.5100
10 px 16.5100 $ 11" + 1" water
11 pz -3.7151
12 pz 3.7151 $ 2.5" + 1" water
c ----- boat + 1" h2o for all other boats -----
52 py -6.3510
53 py 6.3510 $ 5" + 1" water
54 px -13.9710
55 px 13.9710 $ 11" + 1" water
56 pz -3.1751
57 pz 3.1751 $ 2.5" + 1" of water on top of boat only
c ----- glovebox ----- 14"x6.5"x3.5" -----
13 py 0.0000
14 py 106.6900 $ 42" ( 3.5') wide of glovebox
15 px 0.0000
16 px 426.7200 $ 168" (14.0') long of glovebox
17 pz 0.0000
18 pz 198.1200 $ 78" ( 6.5') deep of glovebox
c ----- glovebox + 12" h2o -----
19 py -30.4800 $ + 12" side (-y dir.)
20 py 137.1600 $ 42" ( 3.5') wide of glovebox + 12" side (+y dir.)
21 px -30.4801 $ + 12" side (-x dir.)
22 px 457.2000 $ 168" (14.0') long of glovebox + 12" side (+x dir.)
23 pz -22.8600 $ + 6" bottom (-z dir.) + 3"

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c 24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c ----- glovebox + 12" h2o -----
c 19 py -2.5401 $ + 1" side (-y dir.)
c 20 py 109.2201 $ 42" ( 3.5') wide of glovebox + 1" side (+y dir.)
c 21 px -2.5401 $ + 1" side (-x dir.)
c 22 px 429.2601 $ 168" (14.0') long of glovebox + 1" side (+x dir.)
c 23 pz -2.5401 $ + 1" bottom (-z dir.)
c 24 pz 200.6600 $ 78" ( 6.5') deep of glovebox + 1" roof (+z dir.)
c -----
c ----- sweeps ----- 0.5 liter, 1/4*pei*d*d*h=500cc, h=d=8.6 cm, r=4.30 cm -----
c ----- sweeps ----- 0.5 liter, 1/4*pei*d*d*h=500cc, h = 6 cm, r=5.15 cm -----
c 25 pz 0.002
c 26 cz 5.15023
c 27 pz 6.0000
c ----- sweeps + 1" h2o -----
c 28 pz 0.001
c 29 cz 5.15033 $ 4.30 + 2.54 = 6.84
c 30 pz 6.0001 $ 8.60 + 2.54 = 11.14
c ----- precipitate tank ----- 6.3" dia. 26" T 12 liters ----- TK-001A/B/C ---
c ----- phase separator tank ----- 6.3" dia. 26" T 12 liters ----- TK-004 ---
c 31 pz 0.0020
c 32 cz 8.0010
c 33 pz 109.6400 $ 42" x 2.54 = 106.68
c ----- precipitate tank + 1" h2o -----
c ----- phase separator tank + 1" h2o -----
c 34 pz -2.5401
c 35 cz 10.5410
c 36 pz 112.1800
c 101 pz 15.2400 $ 6" of water surrounding the tanks
c 102 cz 8.0000
c ----- vacuum trap tank ----- 6.3" dia. 22" T 11.1 liters ----- TK-006 ---
c 37 pz 55.6800
c 81 pz 58.3400 $ + 1" h2o
c ----- vacuum catch tank ----- 6.3" dia. 12" T 5.5 liters ----- TK-005 ---
c 38 pz 30.4800
c 82 pz 33.6200 $ + 1" h2o
c ----- polishing filter basin -- 6.3" dia. 16" T duplex ----- FL-002A/B ---
c 39 pz 40.6400
c 83 pz 43.1800 $ + 1" h2o
c ----- vacuum filter basin -- 17" dia. 2" deep ----- FL-001 ---
c ----- drying filter -- 17" dia. 2" deep ----- FL-001 ---
c 41 cz 22.225 $ ID pu(oh)4 precipitate (17.5"/2) * 2.54 = 22.225 cm filter
c 42 cz 23.495 $ OD reflector brick (18.5"/2) * 2.54 = 23.495 cm filter
c 43 cz 34.770
c 44 cz 26.035 $ (20.5"/2) * 2.54 = 26.035 cm 1" of H2O surrounding the filter
c 45 cz 34.855 $ 32.315 + 1"x2.54 = 34.855
c 111 cz 27.805 $ z1 22.225 + 5.58 = 27.805 cm
c 112 cz 32.315 $ z2 27.805 + 5.41 = 32.315 cm
c 46 pz -0.3175 $ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss
c 45 pz -2.8575 $ x for solution [Mg(NO3)2] below 0.3175+ 1"*2.54= 2.8575 cm
c 46 pz -2.9000 $ 1/2" of reflector brick 2.5875+1/2"*2.54= 4.1275 cm
c 47 pz -2.9900 $ 1" of H2O 4.1275+ 1"*2.54= 6.6675 cm
c 48 pz 0.3175 $ (.25"/2) * 2.54 = 0.3175 cm 1/4" ss
c 49 pz 2.1791 $ y for precipitate [Pu(OH)4] above 0.3175+ .73"*2.54= 2.1791 cm
c 113 pz 5.6515 $ 2.1791+ 3.4724 =5.6515 cm (2.1")
c 50 pz 8.1915 $ 1" of water 5.6515+ 2.54= 8.1915 cm
c 51 pz 8.3000 $ 1" of H2O 8.7777+ 1"*2.54=11.3177 cm
c ----- drip pan ----- 1'x1.5'x2" or 12"x18"x2" -----
c 61 px -15.2400
c 62 px 15.2400 $ 12"
c 63 py -22.8600
c 64 py 22.8600 $ 18"
c 65 pz -2.5400
c 66 pz 2.5400 $ 2"
c ----- drip pan + 0.001" h2o -----
c 67 py -15.2410
c 68 py 15.2410 $ 12" + 1" water
c 69 px -22.8610
c 70 px 22.8610 $ 18" + 1" water
c 71 pz -2.5410
c 72 pz 2.5410 $ 2" + 1" water
c ----- transfer pump ----- 6.7" dia. x 8" wide ----- p-001a2-----
c 73 pz -10.1600
c 74 cz 8.5090
c 75 pz 10.1600
c ----- transfer pump + 1" h2o -----
c 76 pz -10.1601
c 77 cz 8.5091
c 78 pz 10.1601
c ----- boat + 1" water + 3/4" ss -----
c 84 py -10.7950
c 85 py 10.7950 $ 5" + 1" water + 3/4" ss
c 86 px -18.4150
c 87 px 18.4150 $ 11" + 1" water + 3/4" ss
c 88 pz -7.6200
c 89 pz 7.6200 $ 2.5" + 1" water + 3/4" ss
c -----
c 90 pz 0.3175 $ 1/8" thick layer of 3 g Pu/cc as PuO2 on floor as holdup
c 91 pz 15.2500 $ 6" of Pu solid at bottom of 3 precipitation tanks
c 92 pz 20.3200 $ half of polishing filter height of 16"
c 93 pz 7.9340 $ 3" x 2.54 = 7.62
c 93 pz 13.0000 $
c 100 so 600.000 $ sphere for outside world boundary

```

tr1 383.53 35.56 60.96

\$ tk-001a precipitator tank

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tr2	312.42	35.56	60.96				\$ tk-001b	precipitator	tank
tr3	233.68	35.56	60.96				\$ tk-001c	precipitator	tank
tr4	233.56	81.28	60.96				\$ tk-004	phase separator	tank
tr5	175.26	72.39	40.64				\$ tk-005	vacuum catch	tank
tr6	127.00	72.39	106.68				\$ tk-006	vacuum trap	tank
tr7	388.62	72.39	96.52				\$ fl-002a	polishing	filter
tr8	308.61	72.39	96.52				\$ fl-002b	polishing	filter
tr9	330.00	81.28	50.00				\$ p-001	transfer	pump x=312.24
tr10	70.00	65.00	4.00				\$		drip pan
tr11	200.00	25.00	1.00				\$		sweeps
tr12	144.78	45.00	4.00				\$ fl-001	wet vacuum	filter
*tr13	50.00	65.00	150.00	90	90	0	\$ fl-001	dry vacuum	filter 1
*tr14	70.00	65.00	150.00	90	90	0	\$ fl-001	dry vacuum	filter 2
*tr15	90.00	65.00	150.00	90	90	0	\$ fl-001	dry vacuum	filter 3
c	*tr16	110.00	27.00	10.00	90	0	\$	furnace	boat
c	tr17	25.00	20.00	4.00			\$	hot plate	boat
c	tr18	55.88	95.00	4.00			\$	storage	rack boat 1
c	tr19	96.52	95.00	4.00			\$	storage	rack boat 2
c	tr20	96.52	95.00	40.00			\$	storage	rack boat 3
c	tr21	96.52	95.00	80.00			\$	storage	rack boat 4
*tr22	312.42	35.56	4.00				\$		extra boat
mode	n								
c	m7		8016.50c	-0.888889	1001.50c	-0.111111	\$ rho=1.000000,	water	
c	mt7	lwtr.01t							
c	m8		8016.50c	-0.235000	7014.50c	-0.765000	\$ rho=0.001290,	air	
c	m11	26000.55c	-1.000000				\$ rho=7.84	, ss	
c	m12	1001.50c	-0.076079	8016.50c	-0.608635	94239.50	-0.315286	\$ rho=1.427280,	450 g/l Pu solution
c	mt12	lwtr.01t					\$		filtrate stream
c	m13	1001.50c	-0.0556	8016.50c	-0.4444	94239.55c	-0.500	\$ rho=1.903890,	40 wt% moisture
c	mt13	lwtr.01t					\$		Pu(OH)4 precipitate
c	m14	13027.50c	-0.212	20000.50c	-0.007	9019.50c	-0.014	\$ rho=2.010000,	reflector brick zone
c		8016.50c	-0.497	12000.50c	-0.006	14000.50c	-0.252	\$	
c		22000.50c	-0.012				\$		reflector brick zone
c	m15	1001.50c	-0.66666	6000.50c	-0.33334			\$ rho=0.900000,	polyethylene
c	mt15	lwtr.01t							
c	m21	94239.55c	-0.038000	7014.50c	-0.009000	8016.50c	-0.850000	\$ 40 gPu/L in Pu(NO3)4	
c		1001.50c	-0.103000				\$ rho=1.06327,	h/x=648	
c	mt21	lwtr.01t					\$		for precipitator tank
c	m22	94239.55c	-0.046000	7014.50c	-0.011000	8016.50c	-0.842000	\$ 50 gPu/L in Pu(NO3)4	
c		1001.50c	-0.101000				\$ rho=1.07909,	h/x=525	
c	mt22	lwtr.01t					\$		for precipitator tank
c	m23	94239.55c	-0.059000	7014.50c	-0.014000	8016.50c	-0.829000	\$ 60 gPu/L in Pu(NO3)4	
c		1001.50c	-0.101000				\$ rho=1.10282,	h/x=337	
c	mt23	lwtr.01t					\$		for precipitator tank
c	m24	94239.55c	-0.731000	8016.50c	-0.250000	1001.50c	-0.019000	\$ 3 g Pu/cc in PuO2, h/x=6.23	
c	mt24	lwtr.01t					\$ rho=4.101430,	floor	
c	m25	94239.55c	-0.000001	8016.50c	-0.888105	1001.50c	-0.111834	\$ 10-3 g/L metal h/x=2.7e+7	
c	mt25	lwtr.01t					\$ rho=1.000001,	ps tank	
c	m26	94239.55c	-0.465000	8016.50c	-0.482000	1001.50c	-0.053000	\$ 2.5 kg PuO2, h/x=27	
c	mt26	lwtr.01t					\$ rho=1.927080,	hp boat	
c	m27	94239.55c	-0.500000	8016.50c	-0.444400	1001.50c	-0.055600	\$ 2.5 kg PuO2 50-50 of Pu & water	
c	mt27	lwtr.01t					\$ rho=1.903890,	vacuum filter basin	
c	m28	94239.55c	-0.779500	8016.50c	-0.196000	1001.50c	-0.024500	\$ 1.5 kg, 3 g/cc h/x=7.5	
c	mt28	lwtr.01t					\$ rho=3.848640,	0.5 L sweeps	
c	m29	94239.55c	-0.086000	7014.50c	-0.020000	8016.50c	-0.802000	\$ 100 gPu/L in Pu(NO3)4	
c		1001.50c	-0.092000				\$ rho=1.15800,	h/x=256	
c	mt29	lwtr.01t					\$		for precipitator tank
c	m30	94239.55c	-0.001000	8016.50c	-0.888000	1001.50c	-0.111000	\$ 1 g/L Pu, h/x=26,517	
c	mt30	lwtr.01t					\$ rho=1.00100,	phase separator tank	
c	m31	94239.55c	-0.539000	8016.50c	-0.418000	1001.50c	-0.043000	\$ 2.75 kg PuO2, h/x=19	
c	mt31	lwtr.01t					\$ rho=2.263000,	boat	
c	m32	94239.55c	-0.179000	7014.50c	-0.042000	8016.50c	-0.708000	\$ 250 gPu/L in Pu(NO3)4	
c		1001.50c	-0.071000				\$ rho=1.39550,	h/x=95	
c	mt32	lwtr.01t					\$		for precipitator tank
c	m34	94239.55c	-0.918000	7014.50c	-0.004000	8016.50c	-0.871000	\$ 18.8 gPu/L in Pu(NO3)4	
c		1001.50c	-0.107000				\$ rho=1.02970,	h/x=1421	
c	mt34	lwtr.01t					\$		for precipitator tank
c	m1	94239.55c	-0.730850	8016.50c	-0.250110	1001.50c	-0.019040	\$ rho=4.104800,	qb hold up
c	mt1	lwtr.01t							
c	m2	94239.55c	-0.047700	8016.50c	-0.846500	1001.50c	-0.105800	\$ rho=1.047500,	precipitate tank
c	mt2	lwtr.01t							
c	m3	94239.55c	-0.000001	8016.50c	-0.888888	1001.50c	-0.111111	\$ rho=1.000001,	phase separator tank
c	mt3	lwtr.01t							

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c m4 94239.55c -0.500000 8016.50c -0.444400 1001.50c -0.055600 $ rho=1.903890, vacuum filter basin
c mt4 lwtr.01t
c m5 94239.55c -0.454300 8016.50c -0.485100 1001.50c -0.060600 $ rho=1.758500, hot plate boat
c mt5 lwtr.01t
c m6 94239.55c -0.779500 8016.50c -0.196000 1001.50c -0.024500 $ rho=3.848640, sweep can (a)
c mt6 lwtr.01t
c m9 94239.55c -0.570400 8016.50c -0.381900 1001.50c -0.047700 $ rho=2.182000, sweep can (b)
c mt9 lwtr.01t
c m7 7014.50c 0.790000 8016.50c 0.210000 $ rho=1.001290, air
c m8 1001.50c 0.66667 8016.50c 0.3333 $ rho=1.00, h2o
c mt8 lwtr.01t $ h2o
c m9 26000.55c 0.05536 24000.50c 0.01641 28000.50c 0.01122 $ ss
c 25055.50c 0.00155 42000.50c 0.00126 6000.50c 0.0002003 $ ss
c m10 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 $ Concrete
c 12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157 $ concrete
c 15031.50c -0.0005 16032.50c -0.0009 36084.50c -0.0066 $ concrete
c 20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788 $ concrete
c mt10 lwtr.01t $ concrete
kcode 6000 1.0 10 600
ksrc 383.53 35.56 60.96 $ tk-001a precipitator tank
312.42 35.56 60.96 $ tk-001b precipitator tank
233.68 35.56 60.96 $ tk-001c precipitator tank
233.56 81.28 60.96 $ tk-004 phase separator tank
175.26 72.39 40.64 $ tk-005 vacuum catch tank
127.00 72.39 106.68 $ tk-006 vacuum trap tank
c 388.62 72.39 96.65 $ fl-002a polishing filter
c 308.61 72.39 96.65 $ fl-002b polishing filter
c 330.00 81.28 10.00 $ p-001 transfer pump x=312.24
c 70.00 65.00 10.00 $ drip pan
200.00 25.00 1.00 $ sweeps
144.78 40.00 4.00 $ fl-001 wet vacuum filter
c 50.00 65.00 150.00 $ fl-001 dry vacuum filter 1
c 70.00 65.00 150.00 $ fl-001 dry vacuum filter 2
c 90.00 65.00 150.00 $ fl-001 dry vacuum filter 3
c 110.00 27.00 10.00 $ filter basin boat
25.00 20.00 4.00 $ hot plate boat
c 55.88 95.00 4.00 $ storage rack boat 1
96.52 95.00 4.00 $ storage rack boat 2
c 96.52 95.00 40.00 $ storage rack boat 3
c 96.52 95.00 80.00 $ storage rack boat 4
312.42 35.56 4.00 $ extra boat
100.00 50.00 0.15 $ glovebox floor holdup
200.00 50.00 0.15 $ glovebox floor holdup
300.00 50.00 0.15 $ glovebox floor holdup
prdmj j -300 1 3
totnu
print 128
ctme 360

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APPENDIX D - HAZARD ANALYSIS

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Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
1	Transfer of Pu solution to blend tanks - No Pu in solution reaching blend tanks when expected (Mass - NO) due to misrouting between Pu solution container and blend tanks	Solution leak onto floor of prep glovebox room.	Leak onto floor is critically safe. Procedures/manual operation with visual monitoring.	N/A for Glovebox 3
2	Transfer of Pu solution to blend tanks - No Pu in solution reaching blend tanks when expected (Mass - NO) due to misrouting between Pu solution container and blend tanks	Solution into some other tank in prep glovebox.	All tanks in prep glovebox are critically safe (6" dia.). Procedures/manual operation with visual monitoring.	N/A for Glovebox 3
3	Transfer of Pu solution to blend tanks - No Pu in solution reaching blend tanks when expected (Mass - NO) due to misrouting between Pu solution container and blend tanks	Solution flows into plant vacuum system.	Vacuum system has leak detection leading to shutdown. Vacuum system is critically safe and has criticality controls in place. Procedures/manual operation with visual monitoring.	N/A for Glovebox 3
4	Transfer of Pu solution to blend tanks - No Pu in solution reaching blend tanks when expected (Mass - NO) due to no Pu in transferred solution	None.	N/A	N/A for Glovebox 3

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
5	Transfer of Pu solution to blend tanks - No Pu in solution reaching blend tanks when expected (Mass - NO) due to liquid evaporating from solution in Pu solution container leaving solution too thick to transfer	Increased concentration in solution container.		N/A for Glovebox 3
6	Transfer of Pu solution to blend tanks - More Pu reaching blend tanks than expected due to human error (Mass - MORE)	None. Tanks in the prep glovebox have been analyzed for 20 kg of Pu, and 2 Pu solution containers will not hold that amount.	Procedural limit of handling only one Pu solution container at a time.	N/A for Glovebox 3
7	Transfer of Pu solution to blend tanks - Other chemicals (e.g., organics) entering blend tanks due to a human error (Mass - AS WELL AS)	None related to criticality.	Pu solution container handling controls.	N/A for Glovebox 3
8	Transfer from blend tanks to precipitators - No solution reaching precipitators when expected due to a piping leak while line containment drain pathway to gloveboxes is blocked (Mass - NO)	Leak into plugged containment line.	Piping and piping containment are geometrically favorable.	Not credible.
9	Transfer from blend tanks to precipitators - No solution reaching precipitators when expected due to a piping leak while line containment drain pathway into glovebox 3 is open (Mass - NO)	Solution leak onto floor of <i>prep glovebox</i> room.	Leak onto floor is critically safe. Procedures/manual operation with visual monitoring.	N/A for Glovebox 3

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
10	Transfer from blend tanks to precipitators - No solution reaching precipitators when expected due to a flow reversal through Pump B (Mass - NO)	None.	Design of pump precludes possibility of reverse flow.	Not credible.
11	Transfer from blend tanks to precipitators - No solution reaching precipitators when expected due to a fractured transfer pipe and containment during a seismic event (Mass - NO)	Spray leak of solution from fractured transfer pipe and containment.	Pipe may be seismically qualified. Housekeeping procedures and training - no open containers are normally allowed on the floor.	Not credible per discussion in Section 3.4
12	Transfer from blend tanks to precipitators - No solution reaching precipitators when expected due to a fractured transfer pipe and containment during a seismic event (Mass - NO)	Spray leak of solution from fractured transfer pipe and containment into uncontrolled, non-critically-safe, open container on floor beneath pipe.	Pipe may be seismically qualified. Housekeeping procedures and training - no open containers are normally allowed on the floor.	Not credible per discussion in Section 3.4
13	Transfer from blend tanks to precipitators - Interaction between tank and glovebox contents (Interaction)	Interaction between tank(s) and glovebox contents.	None.	Base case in Section 5.2 (bc)
14	Transfer from blend tanks to precipitators - Increased - reflected tanks (Reflection - FULL)	Increased reflection of tanks.	Criticality drain.	Fire and Seismic scenarios in Section 5.3 (cc5 and cc6)

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Item #	Condition	Hazard/Consequence	Safeguard	Resolution
15	Transfer from blend tanks to precipitators - Optimally-moderated tanks (Moderation - FULL)	Optimally-moderated tanks.	Normal operation.	Optimally moderated solution scenario in Section 5.3 (cc1)
16	Transfer from blend tanks to precipitators with an excessive solution concentration (Mass - HIGH)	Excess Pu mass in solution.	Maximum Pu concentration that remains pumpable is 450 g/L.	Bound by optimally moderated solution scenario in Section 5.3 (cc1)
17	Transfer from blend tanks to precipitators with a high solution temperature (Temperature - HIGH)	Reactivity increase by positive temperature coefficient during neutralization of acid.	Procedures, blend plan.	Too small temperature change to affect reactivity
18	Transfer from blend tanks to precipitators - High volume (Volume - HIGH)	Excess Pu in precipitator.	20 L capacity of tanks.	Base case in Section 5.2 (bc)
19	Filtering feed solution when no precipitation has occurred (Mass - NO)	High Pu concentrations downstream of filter (TK-004, filtrate tanks)	Procedures, blend plan, analysis of feed.	N/A for filtrate tanks for Glovebox 3 Increased concentration in vacuum tanks and phase separator (40 and 65 g/L) (cc2a and cc2b)
20	Filtering feed solution with no Pu in it (Mass - NO)	No criticality concern.	N/A	N/A

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
21	Filtering precipitate with a low amount of Pu in it after lower than anticipated precipitation due to insufficient $Mg(OH)_2$ addition or a bad analysis (Mass - LOW)	High Pu concentrations downstream of filter (TK-004, filtrate tanks)	Procedures, blend plan, analysis of feed.	See Item #19
22	Filtering precipitate with a higher than normal amount of Pu from a higher than expected Pu in the feed due to a bad analysis (Mass - HIGH)	Excess Pu mass in filter.	Procedures, blend plan, analysis of feed.	Filter basin with 5.5 kg solids scenario in Section 5.3 (cc8)
23	Filtering precipitate with an excess of flocculent (Mass - OTHER THAN)	Increase in moderation in filter.	Procedures.	Filter modeled in base case at H/X ratios of 27 and 57. This bounds any credible increase in flocculent
24	Filtering precipitate with a full furnace boat next to the filter (Geometry/Interaction)	Interaction between Pu-bearing items in glovebox.	Procedures	Bound by filter basin with 5.5 kg solids scenario in Section 5.3 (cc8)
25	Filtering precipitate with Operator's hands near filter (Reflection)	Increased reflection	Limited number of gloves available in filter area limits the number of hands that can be near the filter at once.	Base and contingency cases modeled 1 in. water reflection around filter

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
26	Filtering precipitate with high- or low-density material or solutions (Moderation)	Increased range of moderation (H/Pu)	Procedures, control of chemical addition.	Credible range of moderation analyzed for base case
27	Filtering precipitate with a higher than normal amount of Pu from a higher than expected Pu in the feed due to a high concentration in the feed (Concentration - HIGH)	Excess Pu mass in filter.	Procedures, blend plan, analysis of feed.	Filter basin with 5.5 kg solids scenario in Section 5.3 (cc8)
28	Filtering precipitate with a higher than normal amount of Pu from a higher than expected Pu in the feed due to a higher volume of feed than expected (Volume - HIGH)	Excess Pu mass in filter.	Procedures, blend plan, analysis of feed, precipitation tanks' volume.	Filter basin with 5.5 kg solids scenario in Section 5.3 (cc8)
29	Drying precipitate in a furnace boat on hotplate with a higher than expected amount of Pu in the boat due to a higher level of Pu than expected in the feed due to a bad analysis (Mass - HIGH)	Increases Pu mass in boat.	Procedures, blend plan, analysis of feed.	Bound by overloaded boat in boat rack (cc3)
30	Drying precipitate in a furnace boat on hotplate with an increase in moderation as the water in the precipitate cake evaporates (Mass - PART OF, OTHER THAN)	Increases range of H/Pu (moderation)	Small volume of boat and heat capacity of heater compared to glovebox air replacement rate.	Base and contingency cases modeled a conservative range of H/X ratios that bound any increase from evaporation

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
31	Drying precipitate in a furnace boat on hotplate with other materials (e.g., $Mg(OH)_2$, silica, etc.) present in the precipitate cake (Mass - AS WELL AS)	Decreases concentration of $Pu(OH)_4$ in precipitate cake	Condition is normal	Base and contingency cases modeled with Pu metal and water (bc)
32	Drying precipitate in a furnace boat on hotplate while moving a full furnace boat too close to hotplate (Geometry/Interaction)	Increased interaction	Procedures, physical layout of glovebox 3	Bound by extra boat stacked on boat rack (cc4)
33	Drying precipitate in a furnace boat on hotplate with increased reflection due to operator's hands being near the boat (Reflection)	Increased reflection	Operators normally use tongs to move boats inside the glovebox	Base and contingency cases modeled with 1 in. water reflection around boat on hotplate
34	Drying precipitate in a furnace boat with increased moderation due to out-of-specification chemical addition	Increased range of H/Pu (moderation)	Small volume of furnace boat, procedures	Base and contingency cases modeled with Pu metal and water at max moderation (H/X)
35	Drying a more highly concentrated precipitate than expected in a furnace boat due to out-of-specification chemical addition	Increased Pu mass in furnace boat	Small volume of furnace boat, procedures, Pu limit on 3 precipitator tanks, control of chemical addition, procedures.	An increase in concentration will reduce the H/X ratio resulting in a less reactive system when keeping mass constant.

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
36	Drying a larger volume of precipitate than expected in a furnace boat due to an excess amount of precipitate loaded into the boat	Increased Pu mass in furnace boat	Small volume of furnace boat, procedures	Bound by overloaded boat in boat rack (cc3)
37	Pumping solution into filtrate tanks with a high loading of Pu in the polishing filters (Mass - HIGH)	Increased Pu mass	Small volume of polishing filters, procedures, Pu limit on 3 precipitator tanks, control of chemical addition.	Due to smaller size and greater separation from other fissionable material, considered bound by vacuum tank/ phase separator at 40 and 65 g/L (cc2a and cc2b)
38	Pumping $\text{Pu}(\text{NO}_3)_4$ solution into filtrate tanks without precipitation or filtering (Mass - AS WELL AS)	Increased Pu mass	Procedures	N/A for Glovebox 3
39	Pumping filtrate into filtrate tanks with an interaction of the filtrate with items of opposite side of wall from glovebox 4 (Interaction)	Increased interaction	Procedures, markings on floor on other side of wall from glovebox 4	N/A for Glovebox 3
40	Pumping filtrate into filtrate tanks with increased reflection due to operator's hands being around the filtrate tanks (Reflection)	Increased reflection	Limited number of gloves in area of filtrate tanks	N/A for Glovebox 3
41	Pumping $\text{Pu}(\text{NO}_3)_4$ solution at 450 g/L into filtrate tanks without precipitation or filtering (Moderation)	Increased moderation	Procedures	N/A for Glovebox 3

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
42	Pumping Pu(NO ₃) ₄ solution at 450 g/L into filtrate tanks without precipitation or filtering (Concentration)	Increased Pu solution concentration	Procedures	N/A for Glovebox 3
43	Filtrate overflows TK-004/TK-006 and reaches the eductor, leading to solution sprays inside glovebox 3 (Volume - HIGH)	Increased solution volume	Procedures	Not credible for solution sprays inside Glovebox 3 per discussion in Section 3.4
44	A seismic event causes the furnace boat rack to fail, allowing furnace boats to fall together (External events - Seismic)	Decreased spacing	Glovebox 3 is seismically qualified, boat rack is seismically qualified.	Bound by extra boat stacked on boat rack (cc4)
45	A fire sets off fire sprinklers in the room and the fire water enters the glovebox through burned-through top glovebox windows (External events - Fire sprinklers)	Increased reflection	Criticality drain in glovebox 3, fire sprinklers exist only in room, but glove-boxes have a dry chemical fire suppression system.	Fire scenario (cc6)
46	People surround the glovebox (top, sides, and bottom) causing increased reflection (External events - People)	Increased reflection	External dimensions of glovebox	Base and contingency cases model 12 in. around sides and 6 in. on bottom of glovebox
47	Construction activities damage a water line, leading to water falling and pooling on top of the glovebox	Increased reflection	Construction job planning	Base and contingency cases model 1 in. water on top of glovebox

Hazard Assessment of "Magnesium Hydroxide Precipitation Process" Activity Assessment Team: D. M. Carson, H. L. Chang, D. Clapp, J. S. Lan, E. M. Miller, A. L. Ramble, L. J. Rosane, H. Toffer				
Item #	Condition	Hazard/Consequence	Safeguard	Resolution
48	Construction activities cause a person to fall on top of the glovebox	Increased reflection	Fall safety equipment, training	Due to distance of glovebox top from fissionable material and only one person falling, condition considered bound by base and contingency cases which models 1 in. water on top of glovebox

APPENDIX E - MCNP MODEL FIGURES

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Material Numbers	Material Description
1	6 inches of Pu solid (3 g Pu/cm^3 in PuO_2) at tank bottom
7	Water
8	air
11	Stainless Steel
14	Reflector Brick zone
15	Polyethylene
21	40 g Pu/L in $\text{Pu(NO}_3)_4$
22	50 g Pu/L in $\text{Pu(NO}_3)_4$
23	60 g Pu/L in $\text{Pu(NO}_3)_4$
24	3 g Pu/cm^3 in PuO_2
25	$1 \times 10^{-3} \text{ g/L}$ Pu Metal
26	2.5 kg Pu in PuO_2 fill water in interstitial space of a 2.3 L boat
27	2.5 kg Pu in PuO_2 with 50-50% of water in vacuum filter basin
28	1.5 kg Pu in 0.5 L sweeps with 3 g Pu/cm^3
29	100 g Pu/L in $\text{Pu(NO}_3)_4$
30	1 g Pu/L in PuO_2
31	2.75 kg Pu in PuO_2 fill water in interstitial space of a 2.3 L boat
32	250 g Pu/L in $\text{Pu(NO}_3)_4$ for aggregate of unspaced containers

Figure E-1. Modeled Glovebox 3 Configuration

Figure E-2. Component Designations

Figure E-3. Base Case – bcx30.ps

Figure E-4. Base Case – bcx50.ps

Figure E-5. Base Case – bcx130.ps

Figure E-6. Base Case – bcx230.ps

Figure E-7. Base Case – bcx330.ps

Figure E-8. Base Case – bcy25.ps

Figure E-9. Base Case – bcy30.ps

Figure E-10. Base Case – bcy75.ps

Figure E-11. Base Case – bcz11.ps

Figure E-12. Base Case – bcz30.ps

Figure E-13. Base Case – bcz70.ps

Figure E-14. Base Case – bcz125.ps

Figure E-15. Base Case – bcz135.ps

Figure E-16. Loss of Spacing Between Boats – cc10xy.ps

Figure E-17. Aggregate of Unspaced Container – cwcc7yz.ps

Figure E-18. Seismic with Intact Tanks – ncs2z100.ps

Figure E-19. Plutonium Container Against the Glovebox – cc7mat.ps

APPENDIX F - SAMPLE MEASUREMENTS

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Items	Drawing Dimension	Analysis Dimension	As-Measured Dimension	Conclusion
Spacing Between TK-001A to TK-001B	28"	27"	29.5"	Analysis Dimension < As-Measured
Spacing Between TK-001B to TK-001C	31"	30"	31"	Analysis Dimension < As-Measured
Spacing Between TK-001C to TK-004	18"	18"	19.5"	Analysis Dimension < As-Measured
Spacing Between TK-0015 to TK-0016	19"	18"	19"	Analysis Dimension < As-Measured

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APPENDIX G - COMPONENT SENSITIVITY CALCULATIONS

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G.1 Normal Case Study

Normal cases nca and ncb (Table G-1) calculate system interaction for the whole glovebox. Based on the fissionable material contents under the normal operation condition described in Table 2-2, Case nca differs from case ncb only in the contents of the sweeps can. In case nca, the sweeps can contains dense plutonium (1.5 kg of 3 g Pu/cm³ in PuO₂, H/X = 7.5) while ncb maximizes the moderation (1091 g of Pu in water with an H/X = 20). The maximum moderation case was modeled conservatively as theoretical density plutonium in water. The sweeps can model that gives the greater reactive base case is to be used in further calculations. The result shows that the difference between the two calculated neutron multiplication factors is within their statistical uncertainties at the 95% confidence level. Case nca was arbitrarily chosen for the rest of the analysis. The results (k_{eff} 's < 0.8) show that the safety control limits established in the preliminary design (section 4-1) for equipment layout were adequate for criticality safety. These two cases do not show which components are the most reactive or what interactions between equipment are the most important.

Table G-1 lists k_{eff} for various components (tanks, filter, boats etc.) alone and in combinations. These calculations identify the most reactive equipment. Changes to the mass and reflection of other items may not change the entire system k_{eff} unless there is significant interaction between the items in the glovebox. Case nca1 to nca6 gives single item k_{eff} 's. Case nca7 to nca11 gives k_{eff} 's on groupings of equipment. Case nca12 analyzes the boat on the hot plate alone. Case ncbbo calculates the k_{eff} for the whole glovebox. Cases nca1 and nca3 give the results for one and three precipitation tanks (12 liters of 50 g Pu/l per tank), respectively. Comparing these two cases shows that the required spacing does isolate the fissionable material in the tanks adequately. Cases nca2 and nca4 are the corresponding results when the tanks are surrounded by 1 in. of water. Although the k_{eff} 's values are low, the differences between the "with" and the "without" water reflection cases are substantial. Cases nca5 and nca6 show the very limited reactivity of either the vacuum filter basin or loaded boat rack individually.

Case nca7 adds a phase separator tank (1x10⁻³ g Pu/L) and 2 polishing filters to the three precipitator tanks. Case nca8 adds 1 vacuum trap tank and 1 vacuum catch tank (1x10⁻³ g Pu/L). Case nca9 adds the vacuum filter basin (1.8 kg Pu on filter with 50% moisture). Case nca10 adds one furnace boat (1.8 kg Pu metal mixed with water and filling a 2.3 liter volume). The results show very little change from that of the nca3 case of three precipitation tanks. Case nca11 shows the dominating contribution of the boat on the hot plate. The boat on the hot plate is to be covered by a steel and borated polyethylene encasement to shield operators from the radiation. The shield increases the neutron reflection around the boat increasing reactivity. In fact, the reflected boat on the hot plate alone (nca12) has a k_{eff} compatible to that of the whole system (nca and ncb) when boron is not modeled in the polyethylene. When 5% boron is included (nca12) in the polyethylene, the reactivity drops substantially. The neutron absorber is not included in the base case or the contingency analyses for conservatism.

Table G-1. MCNP Calculational Results for Normal Operation Condition

Case ID	Description	k_{eff}	σ
nca	Normal (sweeps can a, see Table 5-1-2)	0.7905	0.00047
ncb	Normal (sweeps can b, see Table 5-1-2)	0.7917	0.00047
nca1	1 precipitator tank holding 12 L of 50 g Pu/L and without water reflection, no other equipment	0.5859	0.00048
nca2	1 precipitator tank holding 12 L of 50 g Pu/L with water reflection, no other equipment	0.7671	0.00046
nca3	3 precipitator tanks each holding 12 L of 50 g Pu/L and without water reflection, no other equipment	0.5952	0.00050
nca4	3 precipitator tanks each holding 12 L of 50 g Pu/L and with water reflection, no other equipment	0.7774	0.00048
nca5	1 vacuum filter basin, no other equipment	0.3866*	0.0006*
nca6	2 boats in storage rack, no other equipment	0.3155	0.00036
nca7	nca3 plus 1 phase separator tank and 2 polishing filters	0.5950	0.00048
nca8	nca7 plus 1 vacuum trap tank and 1 vacuum catch tank	0.5953	0.00048
nca9	nca8 plus 1 vacuum filter basin	0.5958*	0.00092
nca10	nca9 plus furnace boat	0.5966	0.00047
nca11	nca9 plus 1 hot plate with boat	0.7905	0.00046
nca12	Hot plate with boat alone, no other equipment	0.7899	0.00045
ncbbo	ncb with borated (5%) polyethylene	0.5950	0.00049

G-2. Base Case Study**Table G-2. MCNP Calculational Results for Base Case**

Case ID	Description	k_{eff}	σ
bc1	(Three precipitation tanks are filled with 50 g Pu/L solution and 6 in. of Pu solid [3 g Pu/cm^3 as PuO_2] at bottom of tanks. Three other tanks contain $1 \times 10^{-3} \text{ g Pu/L}$ solution. No Pu solution in vacuum filter basin. Polishing filters empty. No reflection water around containers or glovebox.)	0.79052	0.00118
bc2	bc1 plus fill phase separator tank, vacuum trap tank, and vacuum catch tank contain 50 g Pu/L solution.	0.79195	0.00111
bc3	bc2 plus 1 in. of 450 g Pu/L solution below perforated plate in vacuum filter basin.	0.79078	0.00105
bc4	bc3 plus polishing filter half full of 3 g Pu/cm^3 as PuO_2 and 50 g Pu/L solution in the rest from no Pu in filter.	0.79103	0.00096
bc5	bc4 plus 1 in. of water surrounds all Pu containers and no water surrounds glovebox.	0.92874	0.00153
bc6	bc4 plus water surrounds glovebox. No water surrounds Pu containers.	0.81545	0.00141
bc7	bc4 plus 1 in. of water surrounds all Pu containers and outside of glovebox has thick water reflector.	0.94480	0.00153
bc9	Tanks surrounded 1 in. water along 6 in. of length; boats have 1 in. of water reflector on all sides.	0.86351	0.00094
bc10	Tanks surrounded by 1 in. of water along 6 in. of length, boats have 1 in. of water reflector on its top only.	0.86261	0.00096
bc11	bc9 plus 12 in. of water around, 6 in. below, 1 in. on top of glovebox	0.88774	0.00171
bc12	bc10 plus 12 in. of water around, 6 in. below, 1 in. on top of glovebox	0.88589	0.00171
bc13	bc1 without hot plate boat	0.73714	0.00100
bc14	bc13 has 50 g/L solution in place of 6 in. solid Pu in tanks.	0.59772	0.00091
bc15	bc12 with precipitator tanks filled to 20 L, instead of 12 L	0.88697	0.00142

Cases bc1 to bc6 steps from the normal condition (nca) to a more complete model by covering a range of abnormal but anticipated operation conditions. The cases also explore several overly conservative arrangements. These cases are listed to understand the relative reactivity of the different items contributing to the reactivity of the glovebox. Each case adds fissionable mass or reflection. Cases bc9 to bc12 add water reflection. Cases bc13 and bc14 explore some alternate configurations. Case bc15 is defined as the base case. It has all the worst case configurations except that 1" water reflection is limited to a 6" length of the precipitation tanks, which is as much as can realistically be covered by an operator's hands or a damp rag.

Case bc1 adds the first increase in reactivity from the normal operation condition (case nca) to the precipitator tanks. It puts 6" of Pu solid (3 g Pu/cm^3 as PuO_2 saturated with water) at the bottom of the tank and leaves 50 g Pu/L solution for the rest of the 12 L height. Each precipitation tank holds 9.36 kg of plutonium, 8.91 kg Pu of solids and 0.85 kg Pu in the 9 L of solution. Case bc1 fills the three 20.1 L precipitation process vessels with 250 g Pu/L of plutonium nitrate and water solution. This puts the most reactive concentration of plutonium nitrate into the precipitation process vessels. Case bc2 adds to case bc1 the phase separator tank, vacuum trap tank, and vacuum catch tank, each filled with 250 g Pu/L solution. Similarly, case bc3 adds 1 in. of 450 g Pu/L solution below the perforated plate of the vacuum filter basin to case bc2. Case bc4 adds to bc3 the polishing filter half full of 3 g Pu/cm^3 as PuO_2 saturated with water and the other half filled with 250 g Pu/L solution.

Case bc5 puts 1 in. of water around all fissionable containers from case bc4 but without water surrounding the glovebox. Case bc6 reversed the process by surrounding the glovebox with water but no close fitting water surrounds the fissionable material containers. Case bc7, an overly conservative configuration, has 1 in. of water surrounding all the containers including the tanks and has water reflection outside the glovebox also.

Case bc7 shows that having 1 in. of water around the entire precipitation tank exceeds the allowable limit. A more realistic assumption (bc9) would be to surround a tank with a 6 in. length of one inch of water to simulate an operator's hand or a rag. The glovebox does not have sufficient gloveports to get even one pair of hands to each container. After various parametric tests (bc10 to bc14), a base case, bc15, was found that accommodated all the requirements established in Tables 5-2-1 to 5-2-3.

APPENDIX H – BASIS DOCUMENT

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F-1. Flooding Memo

B & W Hanford Co.

a McDermott company

To	A. L. Ramble, Engineer PFP Facility Engineering	TS-54	
From	R. D. Pickett, Cognizant Engineer PFP Facility Systems Engineering	T4-20	File No. or Ref.: 15510-99-RDP-038
Subj	FIRE FLOODING AND SPRAY ANALYSIS FOR ROOM 638	Date: May 17, 1999	

Reference: Telephone Request for Fire Water Flooding and Spray Analysis, dated May 7, 1999.

ASSUMPTIONS

- Fire department on scene within 40 minutes (see FSAR section 9.2.2A).
- 120 psi at each sprinkler head (this is very conservative since line losses and operation of other sprinkler heads would decrease this pressure).
- Fight a fire with two hoses for a total of 400 gpm (one hose at 100 gpm and second hose at 300 gpm per information provided by the fire department). Note: these hoses are variable stream types so the pattern and flows are adjustable.
- For flooding, assume all sprinkler heads operate (this is worse than a shear of a 1 1/2" water line).
- 1 second of flow from a sprinkler head or hose will suspend the amount of water to achieve the maximum density.
- Assume 3 sprinkler heads worth of flow into the cage area.
- No leakage out of the room.
- There is 8 lb. Water in 1 gallon.
- Exclude floor space and volume of room 639 and 640.

BACKGROUND

- Area of the room floor = 130 ft².
- 14 sprinkler heads in the room (see CVI 21097)
- Sprinklers have a 1/2" orifice with a 5.62 K-factor.
- There are 7.481 gallons per ft³.
- Occupational Classification is Ordinary Hazard (see CVI 21097).
- Caged area has two sprinkler heads.
- Ceiling height is 9' 6".
- Floor dimensions of caged area 7' x 18' 3"
- Probability of fire not being noticed and the fire department being delayed 30 minutes is discussed in section 9.2.2A of the FSAR.
- Flooding cannot occur when a fire hose is used since the doors to the room have to be open along the hose route all the way to the outside of the building. There are no hose connections inside 2736-ZB or 2736-Z.

A. L. Ramble, et. al.
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CALCULATIONS

Flow per sprinkler head = $Q = K \sqrt{P} = 5.62 * \sqrt{120} = 61.56 \text{ gpm}$

Sprinkler flow into cage area = $3 * 61.56 = 185 \text{ gpm}$

Sprinkler flow into the whole room = $14 * 61.56 = 862 \text{ gpm}$

Volume of cage area = $7' * 18' * 9.5' = 1200 \text{ cu. ft.}$

CAGE DENSITY CALCULATIONS

Cage Density during fire fighting in cage area = 185 gpm from sprinklers + 400 gpm from fire hoses = 585 gpm total flow.

Water released in 1 second of sprinklers and hoses = $585 \text{ gpm} * (1 \text{ min}/60 \text{ sec}) * 1 \text{ sec} = 9.75 \text{ gal.}$

Water density in cage area = $9.75 \text{ gal}/1200 \text{ cu. ft.} = 0.0081225 \text{ gal/cu. ft.}$

FLOODING CALCULATIONS

Volume of water release in 40 minutes = $40 \text{ min} * 862 \text{ gpm} * (1 \text{ cu. ft.}/7.481 \text{ gal}) = 4609 \text{ cu. ft.}$

Water level after 40 min. = $4609 \text{ cu. ft.}/1340 \text{ sq. ft. floor area} = 3.44 \text{ ft.}$

CONCLUSIONS

After 40 minutes of sprinkler flow, the water level in room 638 will be 3.44 feet. The maximum density of water suspended in the cage area is 0.008-gal/cu. ft.

klm

Distribution

Fluor Daniel Northwest

K. D. Dobbin	B4-44
J. S. Lan	B4-44
J. A. Miller	B4-44
RDP File/LB	

F-2. Density Memo

FLUOR DANIEL HANFORD, INC.**I N T E R O F F I C E C O R R E S P O N D E N C E**

To: E. M. Miller, B4-44 Date: March 9, 2000
From: S. A. Jones T5-12 Telephone: 373-3347
cc: File No. 1AF00-00-022
Subject: MAGNESIUM HYDROXIDE CALCINED PRODUCT WATER CAPACITY

This letter transmits the results of a test performed in the Plutonium Process Support Laboratories (PPSL) to measure the void volume and capacity to hold water of a calcined product resulting from magnesium hydroxide precipitation and calcination of plutonium from nitric acid solution. The information is provided to support criticality safety analyses.

The item tested was a precipitate from magnesium hydroxide process testing that had been filtered, washed with water, and dried in a muffle furnace heated to 1000 °C. A loss-on-ignition (LOI) analysis of this material result was 0.49% weight loss. It was assumed that the magnesium hydroxide ($\text{Mg}(\text{OH})_2$) had been converted to magnesium oxide (MgO) in the furnace and that plutonium was present as plutonium dioxide (PuO_2) in the dried solid. Chemical assay of the dried precipitate was performed with the result that this material contained 31% plutonium. Converting this to PuO_2 , there was 35% PuO_2 by weight. It was assumed for calculations that the remaining weight was due to MgO although other metal impurities from the test solution are included in this material.

The density of dry precipitate was measured by breaking up any large chunks of solid until all solid was a fine powder. This was easily accomplished manually by pressing a spatula against the large pieces. The powder was scooped into a tared graduated cylinder that was filled to the 50-mL line. The weight of the cylinder and powder was measured and the net solids weight was 29.5 grams. The cylinder was then tapped on the floor of the glovebox until not further solids reduction was observed. This final volume was 37 mL. From these values, the bulk density was 0.59 g/cc and the tap density was 0.80 g/cc.

The graduated cylinder was emptied, rinsed with water, tared, filled to the 25 mL mark, and weighed. Solid was added slowly until all free water had been absorbed. This point was determined to be when no free liquid was visible on the surface of the solids. In this test, 23.7 g was absorbed by 25.7 mL of water and the final volume of the wet solids was 30 mL. From the tap density of the dried precipitate, 23.7 g would occupy 30 mL.

Water-saturated calcined product contained 52% water. Using 65 wt% MgO in the solid, it was calculated that 7 mL H_2O would be required to convert MgO to $\text{Mg}(\text{OH})_2$. It is uncertain the rate at which this conversion will occur in the calcined product. If MgO converts to $\text{Mg}(\text{OH})_2$, the remaining 19 mL of water in this test fills the void volume in the precipitate. This represents 63% of

A-6002-122 (08/98)

FLUOR DANIEL HANFORD, INC.**I N T E R O F F I C E C O R R E S P O N D E N C E**

E. M. Miller

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the solid volume. If the conversion does not occur, the void volume is 25 mL out of 30 mL or 87%. This does not change the conclusion that the solids contained 52% water by weight.

It should be noted that these observations are for a single test with a single batch of precipitate. The character of the calcined precipitate appears to be largely governed by the properties of magnesium oxide. In other testing, the highest plutonium concentration observed was 61 wt%. Depending on impurities in the feed solution, the plutonium concentration may be very low.

Raw data and calculation results are listed in the table below for your information. If further explanation of this test is required, please feel free to contact me.

Precipitate Density Measurements, Dry	
Empty Graduated Cylinder Weight, g	21.047
Graduated Cylinder Weight with 50 mL Dry Precipitate	50.569
Precipitate Weight, g	29.522
Precipitate Bulk Density, g/cc	0.590
Volume of Precipitate, Tapped Down, cc	37
Precipitate Tap Density, g/cc	0.798
Precipitate Density Measurements, Wet	
Empty Graduated Cylinder Weight, g	22.061
Graduated Cylinder Weight with ~25 mL Water, g	47.741
Graduated Cylinder Weight Water + Dry Solids, g	71.45
Dry Solids Weight Added to Water, g	23.709
Wet Solids Weight, g	49.389
Final Volume of Wet Precipitate, cc	30
Density of Wet Solids, g/cc	1.65
Volume of Precipitate, cc (using tap density)	29.7
Precipitate Composition	
Solids Plutonium Content, %	31
Solids PuO ₂ Content, %	35
Solids MgO Content, %	65
Solids MgO Content, moles	0.38
Water to Hydrate MgO, g	6.9
Free Water, g	18.8